This Month's Cover: Cutaway view of General Electric Co. J 47 turbojet engine. Most powerful of the jets, it delivers 5000 pounds of thrust.

MACHINE DESIGN

Vol. 22—No. 3 March, 1950

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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Published by
THE PENTON PUBLISHING COMPANY
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NEW EQUIPMENT DIGEST

Published on the seventh of each month. Subscription in the United States and possessions, Canada, Cuba, Mexico, Central and South America: One year $10. Single copies, $1.00. Other countries one year, $15.

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Acceptance under Act of June 5, 1934. Authorized July 20, 1934.

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DESIGNING FOR PRODUCTION AND SALES • STYLING
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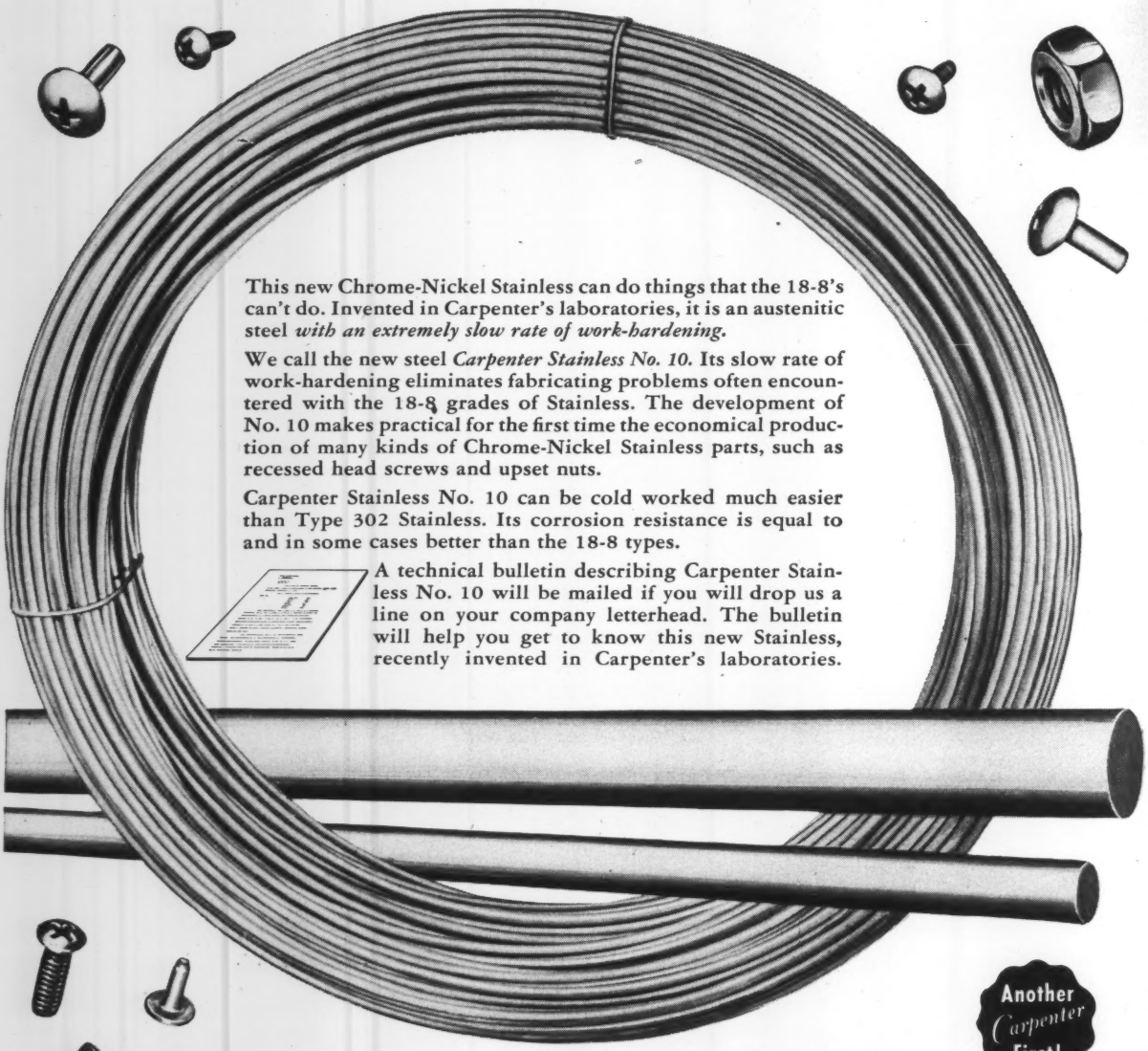
MACHINE COMPONENTS • ENGINEERING MANAGEMENT

MD

a NEW STAINLESS STEEL has been invented by *Carpenter*...



This new Chrome-Nickel Stainless can do things that the 18-8's can't do. Invented in Carpenter's laboratories, it is an austenitic steel *with an extremely slow rate of work-hardening.*

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more than corrosion resistance

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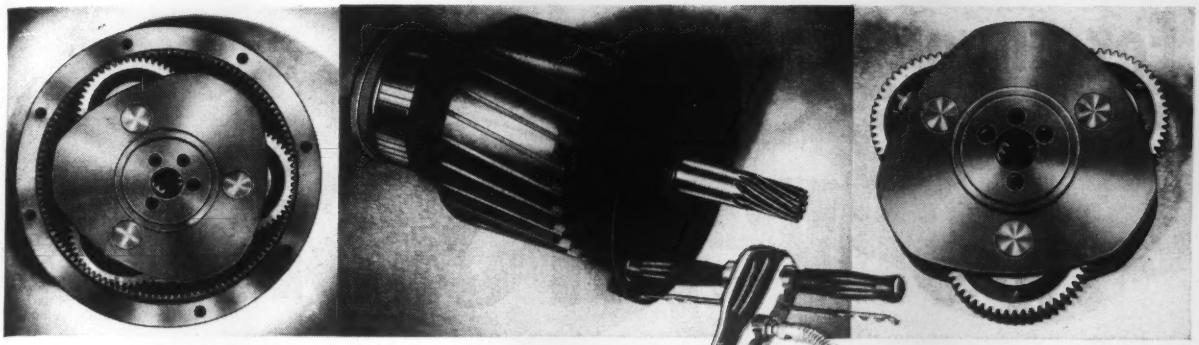
(Patent Pending)

FOR COLD HEADED AND UPSET PARTS

Type Analysis: Carbon...0.08% max. Chromium...16.00% Nickel...18.00%



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Proved in installations operating under rugged conditions, in temperatures from below zero to desert heat, and exposed to dust and dirt . . . carriers developed around these lubricated-for-life conveyor bearings are giving years of service without any cost for greasing.

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Nothing Rolls Like a Ball . . .

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BALL BEARINGS

90

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Classified for convenience when studying specific design problems

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New Federal Noark Protectit is today's outstanding fractional horsepower manual motor starter

THERE'S A WIDESPREAD NEED for small motor starters . . . and you'll meet it in a big way with the new Noark Protectit. This compact, modern device provides dependable automatic overload protection and is designed throughout for truly superior service.

The new Noark Protectit has double-break silver contacts welded to phosphor bronze contact springs. Reset after tripping is automatic. Individual arcing chambers confine each arc and assure rapid extinction. The bimetallic overload element is time-proven and accurate. Overload relay heaters are conveniently mounted from the front of the Protectit with a single screw.

New Noark Protectits are rated in 1 h.p., 115-230 V., single phase A. C., and in ¾ h.p., 115-230 V., D. C. Surface enclosure and open types; flush mounting Protectits using standard flush plate available. Order from your Federal Distributor. And have him send you a descriptive folder. Federal Electric Products Company, 50 Paris Street, Newark 5, New Jersey.

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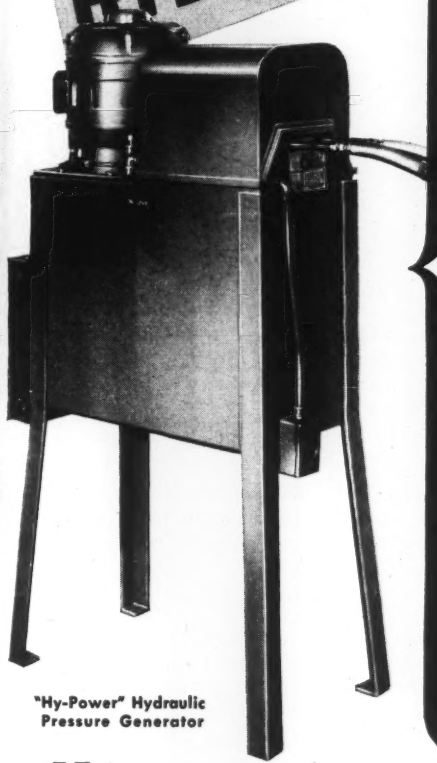
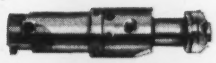
HANNIFIN "Hy-Power" HYDRAULICS

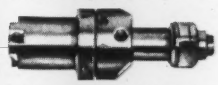


"Hy-Power" Hydraulic Pressure Generator

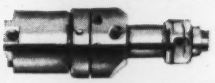


7½ tons capacity "Hy-Power" cylinder.

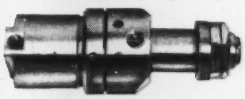
10 tons capacity "Hy-Power" cylinder.



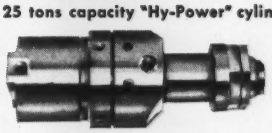
12½ tons capacity "Hy-Power" cylinder.



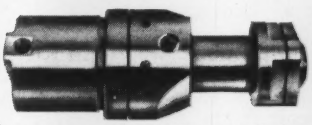
17½ tons capacity "Hy-Power" cylinder.



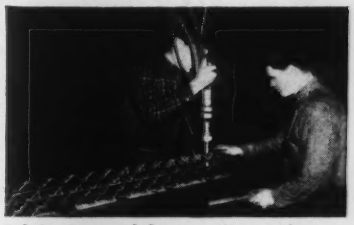
25 tons capacity "Hy-Power" cylinder.



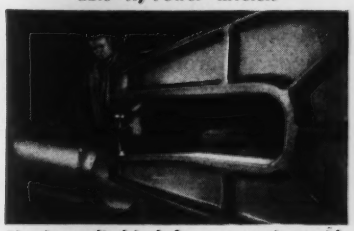
35 tons capacity "Hy-Power" cylinder.



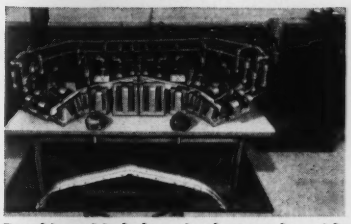
50 tons capacity "Hy-Power" cylinder.



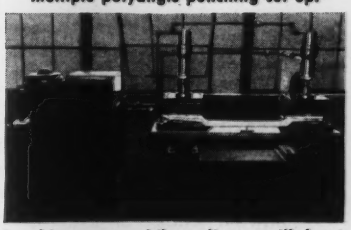
Fabricating steel floor gratings with portable "Hy-Power" Riveter.



Riveting cylindrical furnace section with stationary "Hy-Power" Riveter.



Punching 16 holes simultaneously with multiple polyangle punching set-up.



Punching automobile radiator grill base bars with "Hy-Power" units.

Heavy duty multiple punching machine for automobile frame side rails.

HERE is an opportunity for design engineers and tool makers interested in securing simple, easy to use, "cost reducing" production equipment for a minimum investment! HANNIFIN "HY-POWER" HYDRAULICS has brought about an entirely new concept of the high speeds and extreme forces that can be developed hydraulically with small, compact, automatic work units. "Hy-Power" Hydraulic Pressure Generators give you up to 5,000 p.s.i. pressure at your finger-tips under instant, safe, automatic control. When applied through one or more "Hy-Power" Hydraulic Cylinders, almost any desired force is available for performing a wide variety of riveting, punching, pressing, shearing, forming, multiple riveting, multiple punching, and similar operations. Hannifin engineers will be glad to cooperate with you in supplying "Hy-Power" pressure generators and cylinders for machines of your own design or in supplying complete "Hy-Power" work units. Send for information.

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Discuss "HY-POWER" HYDRAULICS with Hannifin Engineers at the Tool Show in Philadelphia — Booth 215

TOPICS

VARIABLE-SCALE ruler, 12 inches long, is fitted with a triangular coil spring which, when expanded or contracted, spaces intermediate points proportionately. When fully compressed the scale has 100 markings to the inch. Dividing, proportioning and interpolation are facilitated.

PAINT made of resins, oils and waxes but no solvents is applied with a spray gun in which both the paint and surface are heated. Having no solvents to evaporate and leave a porous film, the paint has three times the life of ordinary paints according to its manufacturer, A. B. Antros, Sweden.

XEROGRAPHY, new method of reproducing drawings and documents, employs a charge of static electricity on a sensitive metal plate and is expected to provide the U. S. Air Force with enlargements of microfilmed drawings at a fraction of their present cost. The selenium-coated plate is charged with electrons. During exposure in the camera, the electrons escape from the areas which receive light but are retained on the dark areas. Powder dusted on the plate remains only on areas with electrons. This powder image is transferred to paper and made permanent by heat.

MERCURY TYPE BATTERY, used in the Air Force's new air-sea rescue transmitter receiver, will not deteriorate with lack of use or with age. Replacing the Gibson Girl, the unit is far less cumbersome and much more reliable.

FLUXES for difficult soldering jobs, developed in England, are being distributed by Newage International Inc., New York City. Known as T.S.F. fluxes, they are self-cleaning, remove oxides and film from ferrous and nonferrous metals, are impervious to grease, do not corrode or rust, and evaporate from the finished job without leaving a halo.

EXTRUDED ALUMINUM pipe will be used for the first aluminum gas line. An all-welded line will extend underground 1.8 miles in the Alabama-Tennessee Natural Gas Co. system.

ELECTRICAL NOISE or microphonism caused by mechanical vibration of electronic tube elements is an important consideration in the application of instruments to aircraft, guided missiles, automotive vehicles and industrial machines, according to Lester Feinstein, Sylvania Electric Products Inc. Vibration of the mounting and rattle or resonance of the tube elements are causes of microphonism. Work on improving tubes to make them insensitive is under way.

GALLIUM, produced in commercial quantities in high purity metallic form by the Aluminum Co. of America, has unusual properties. Melting at body temperature, it has a wide liquid range and will not boil until it reaches 3600 F. It expands on solidification and wets the surface of many materials.

RUBBER PARTS in a 1950 automobile, exclusive of tires and tubes, involve 350 to 400 parts, weighing 70 to 100 pounds, according to the Goodyear Tire & Rubber Co. In 1925 the average car used about three pounds, exclusive of tires and tubes.

FRICTION MATERIAL, for brakes and clutches, made by fusing woven asbestos tape with Bakelite phenolic resin, has been reported to be the most serviceable type used by New York taxicabs.

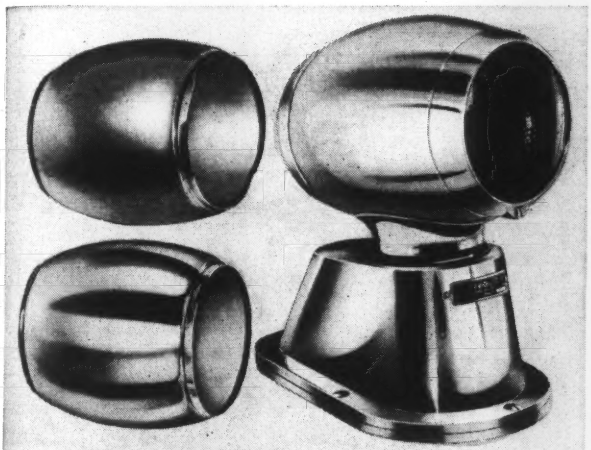
COINING silver alloy washers from round wire rings effects savings up to 50 per cent over conventional stamping methods. Used for silver brazing preforms, the method was developed by the Lucas-Milhaupt Engineering Co.

LUBRICANT containing molybdenum provides a permanent low-friction antiseizing coating and lubricates high-speed and high-pressure bearings effectively at either red heat or subzero temperatures, according to the Lockrey Co. Molybdenum, being extremely greasy and practically indestructible at high temperatures and pressures, has the peculiar faculty of plating itself to any friction surface.

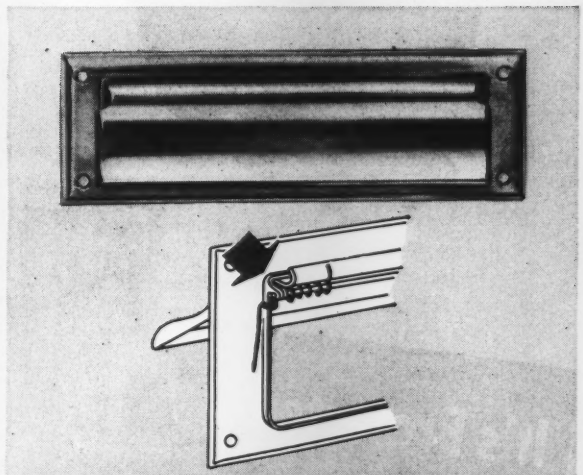
2 MORE EXAMPLES

how manufacturers improved their products . . . cut production costs with the aid of

REVERE PRODUCTS and SERVICE



UPPER LEFT shows brass shell of the Rev-O-Lite as it comes from the bulging die. Without any extra finishing, which would have been necessary had shell been made of strip and brazed, shell is chrome plated as shown at lower left. At right is the completed assembly of the Rev-O-Lite ready for action on the roofs of all kinds of emergency vehicles such as police patrol cars, ambulances, fire trucks, etc. Chrome finish base is of cast zinc alloy.



THE LETTER BOX PLATE that is not only one of the first to be made from wrought brass but, the Ives Company tells us, has been generally accepted by the trade as the equal of similar items in cast brass. Another example of what can be accomplished when manufacturer and supplier work together.

Line drawing directly above shows detail of construction with Ives exclusive, Weather-Tite interlocking feature.

1. In the development of their Rev-O-Lite, a revolving warning light for emergency vehicles, the Balford Corporation, Jacksonville, Florida, found themselves faced with a production problem regarding the cylindrical shell which contains the lights. The question was; what would be the most efficient and economical way to produce this shell that measures 6″ in length and is 4½″ in diameter at the ends? Should it be formed from a metal strip and brazed? Could tube be used and bulged in a die? Or, should some other method be employed.

Revere, working with the design engineers of the Balford Corporation, exchanged ideas, weighed the pros and cons of various methods; experimented. They found that by using 70/30 Revere Brass Tube in a light anneal temper, it would take the bulging in the die satisfactorily and at the same time show up well as far as grain size control was concerned. By this method, complicated and costly forming operations and brazing could be eliminated; production speeded and the shell formed without any unsightly seam. Also, no extra hand finishing would be necessary before plating.

2. How can you make a letter box plate out of wrought brass and at the same time have it look like cast brass? This problem of the H. B. Ives Company, New Haven, Conn., came up while the Ives engineers were designing a new type plate employing a new method of interlocking the flap and the frame of the box to insure its being weather-tight.

Casting was ruled out as too costly and impractical to construct. If brass strip was used it had to be heavy enough to simulate cast hardware, yet sufficiently flexible to complete a U bend on a 7″ length without fracture or distortion. Also, because the finished plate would in most cases call for a natural brass finish, the stock had to be the right color.

After several consultations with Revere Technical Advisory Service and experiments in their own shop, it was suggested that Revere sheet brass of .062″ thickness and of a certain temper be used. That was it! The combination of proper design and heavy gauge metal resulted in a neat but rugged appearance. The wrought construction made it possible to produce a Weather-Tite plate with exclusive interlocking feature without costly machining operations. In addition, finishing costs were reduced to a minimum.

Perhaps one of the many types of Revere Brass or one of the other Revere Metals or Alloys can help you improve *your* product—cut your production costs. Why not tell Revere's Technical Advisory Service about *your* metal problems? Call the Revere Sales Office nearest you today.

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Here's Another Motor that Won't Burn Out...

It's Protected by the Built-in KLIXON Protector

KLIXON PROTECTORS Prevent Motor Burnouts, Reduce Repairs and Replacements

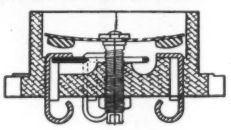
Burnout . . . not the motor illustrated because the motor manufacturer has included inherent overheat protection by building-in a Klixon Protector.

Out of sight and out of mind, the Klixon Protector keeps constant guard . . . always ready to shut the power "off" should the motor become dangerously overheated. When it cools to a safe operating temperature it snaps the power "on" again automatically. And because it is built-in by the manufacturer, the Klixon Protector and motor provide a tested combination that assures long motor life.

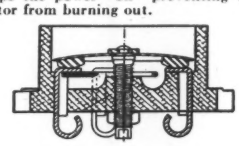
Motor manufacturer after manufacturer extend the life line of their motors by including Klixon Protectors . . . automatic reset types that recycle automatically . . . manual reset types that require the "red button" to be pushed to reclose the circuit.

Protect your motor-driven products by using and specifying motors with built-in Klixon Protectors. Also request that transformers, solenoids, variable voltage transformers and other electrical equipment have Klixon overheat Protectors.

HOW KLIXON PROTECTORS WORK!



CLICK . . . IT'S OFF!
Should a motor become overheated and dangerously hot, the Klixon Protector snaps the power "off" preventing the motor from burning out.



CLICK . . . IT'S ON!
When the motor cools to safety, the Klixon Protector snaps the power "on" automatically, or by pushing the red button when the manual reset type is used.

SPENCER THERMOSTAT Division of Metals & Controls Corporation — KLIXON — **2503 Forest St., Attleboro, Mass.**

MACHINE DESIGN
A PENTON PUBLICATION

Machines Are Run by People

WITHOUT its human operator the best machine in the world is a mere assembly of parts and materials. It takes the brains and muscles of men and women to give it life and keep it functioning. To suggest that designers don't realize this fact may sound insulting, but there is ample evidence of failure on the part of engineers to regard the operator as an integral part of the machine just as much as the mechanical, electric, or hydraulic controls.

No reputable engineer would attempt to design a machine without strict observance of scientific facts, yet too often designs are completed in disregard for the physiological and psychological facts that govern the operator's behavior. To an extent the marvelous adaptability of the human body and mind can overcome these limitations, but only to an extent.

Examples of this weakness in design were encountered during the war when superior equipment seemingly failed to provide the quality results that were expected. Aircraft instrument dials were so designed that the pilot could, and did, read altitude incorrectly by increments of 1000 feet. Similarly, field artillery micrometer azimuth scale errors of 100 mils proved a serious problem. Antiaircraft equipment of high response and speed proved disappointingly slow in actual combat owing to human inability to correlate all manual operations speedily. Why? Instruments or controls, or both, had not been properly engineered to match the essential human servo link.

Much can be done to insure that machines really "fit the man" as they should. Among the little explored means by which the designer can supplement his native horse sense in achieving this end is the application of time and motion study procedures to the design of machine controls. Elsewhere in this issue the techniques are explained, using a simple production machine as an illustrative example. The principles are just as applicable to the housewife operating her electric ironing machine or to the pilot taking his plane off the ground. An important effect of the technique described is that it brings the operator definitely into the picture even to the extent of physical representation by a template. The designer is thereby forcefully reminded of the operator's presence and his vital part in the smooth functioning of the man-machine team.

Colin Carmichael

EDITOR

Improving Machine Design

...through application of motion study principles

By Dr. M. E. Mundel
Purdue University
Professor of Industrial Engineering

Fig. 1—Symbols used in man and machine operation charts. Specific meaning is given for action represented when symbol is used with man or machine

Symbol	Name	With Man	With Machine
○	Suboperation	Body member or operator doing something at one place	Machine working ("on" time), machine paced
?	Suboperation	Not used	Machine working ("on" time), operator paced
→	Movement	Body member or operator moving toward or with an object	Not used
○	Hold	Body member maintaining an object in a fixed position	Not used
▽	Delay	Body member or operator is idle	Machine is idle ("down" time)

MUCH has been written to illustrate the excellent effects that can be obtained by applying the critical analyses of motion study to the redesign of machines, jigs, fixtures, and tools. The machine designer has been frequently castigated either directly, or by inference, for his failure, when designing, to take the human operator into account. This article, without attempting to enter into a discussion of the fairness or unfairness of this charge, presents an extremely simple technique to obviate this failure in design. The procedure outlined should enable a machine designer to test his plans prior to the construction of the equipment in order to

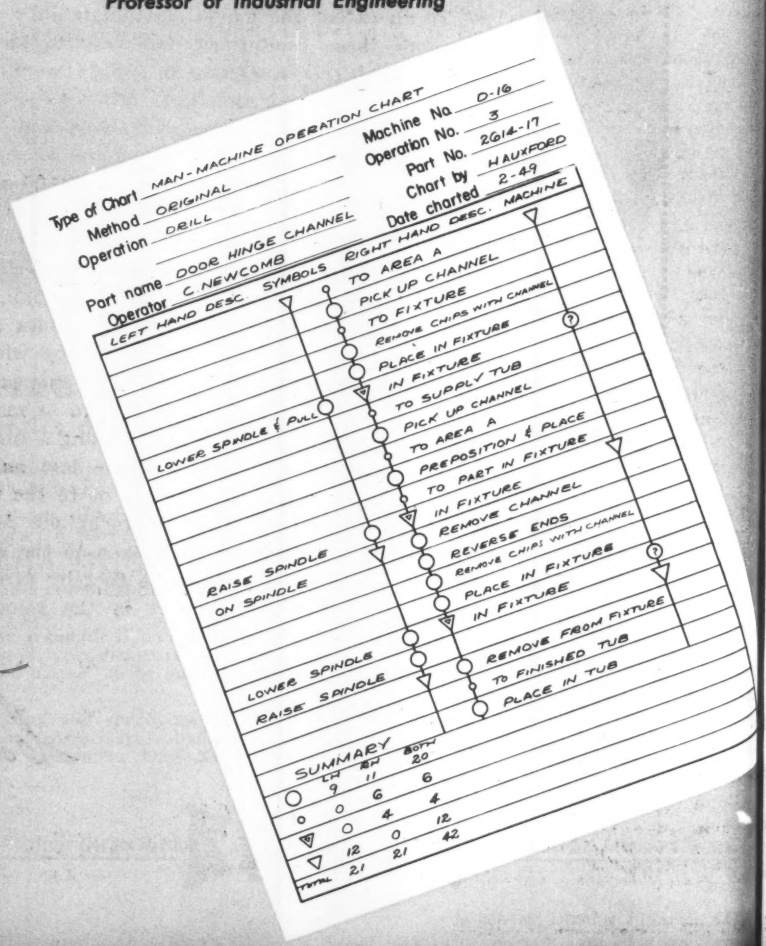


Fig. 2—Right—Typical man and machine operation chart. This chart is actually that for original method of "Drill Holes in Hinge Channel", an example selected for simplicity. Each symbol shown repeats at each step until a new symbol appears

determine the suitability of the design for ease of human operation and to remedy any shortcomings he may discover. The machine designer must learn only three things in order to do this easily and effectively:

1. How to make a man and machine operation chart
2. How to make a human template
3. How to use these two tools to produce more usable equipment.

These three steps are detailed in the subsequent portions of this article.

M-M Chart Gives Detail Analysis

MAN AND MACHINE OPERATION CHART: A man and machine operation chart is a graphic means of portraying the separable steps performed by a person's body members when he is doing a job which takes place essentially at one location, and also indicates the actions of the equipment and its relationship to the man work. It is basically a description, in graphic form, of what the operator and his equipment do. The symbols used and the steps which are separately identified are shown in *Fig.* 1.

Basic steps in making a man and machine operation chart are as follows:

1. Chart should be constructed after the preliminary assembly drawings or sketches of the equipment are made
2. A form such as that used in the illustrative example of *Fig.* 2, or a blank sheet of paper, may be used
3. Although the chart may begin at any point in the cycle of work it is usually most convenient to begin with the first hand motion (or movement of the operator) attributable to a specific part.* (A cycle of work is taken to be the complete pattern of motions required to bring a unit of the product to the stage of completion typical of the operation)
4. A method of operating the machine should be assumed by the designer and the first step of the hand which begins the cycle should be classified into the proper category according to *Fig.* 1 and an entry made on the first line as was done in *Fig.* 2
5. Action planned for the other hand at this same time should be placed on the same line opposite this first symbol
6. Similarly, all the motions of both hands should be placed on the chart, care being taken to show on any one line only those actions which take place simultaneously
7. Using the appropriate machine symbols from *Fig.* 1, the machine sequence is detailed in the third column, care being taken to place the appropriate symbols on the proper lines so as to indicate the planned simultaneity of man and machine actions.

The man and machine operation chart shown in *Fig.* 2 is for the task of "Drill holes in hinge channel" using a special drill setup. This is an extremely simple application and has been chosen so that the illustration of principle and procedure is not masked in a maze of details.

Since this machine has been put into use, a picture of it is available and is shown in *Fig.* 3. Assuming this motion analysis work had been done at the proper time the machine designer would have had available only drawings of the equipment as shown in *Fig.* 4, which shows the data needed.

HUMAN TEMPLATE: Templates are given in *Fig.* 5 for a human plan and profile view. By cutting out parts to the indicated scale and assembling them an articulated template is obtained for use on scale drawings of equipment. With this template the machine designer is equipped to apply these techniques to actual design.

HOW TO CHECK AND IMPROVE EQUIPMENT DESIGN: Place the appropriate templates in position on both a plan and a profile view of the equipment, move the template's body members to the position required to perform the first step on the chart, apply the following check list questions to the step (as applicable), keeping the objectives in mind, and repeat this procedure for each step.

Check List For Design

OBJECTIVES

A. Minimum number of steps
B. Easiest steps
C. Least movements
D. Use of both hands
E. Avoidance of awkward positions, movements and postures
F. Staying in normal work area
G. Reducing down-time
H. Doing as much as possible during machine on-time.

CHECK LIST QUESTIONS

1. Can a suboperation be elimianted?

a. As unnecessary
Can the control, feed, adjustment, etc., be incorporated into the equipment or given to the feet?
b. By a change in the order of work
c. By a change of controls
d. By a change in layout of equipment or supplies
e. By combining controls
f. By a slight change in specifications of raw material
See designer of product
g. By a slight change in product
See designer of product.

2. Can a suboperation be made easier?

a. By better handles
Handles should allow maximum flesh contact, without sharp corners, for power; small diameter for speed without power. Use template to determine if they are in a convenient position
b. By changing leverage
Use human template to check position of pull, effective leverage, increase or decrease as necessary
c. By changing position of controls
Are they near the correct hand and in the normal work area or can they be moved into it? Use template to check. Make sure pedals do not require a balancing act

* The first and last cycle of a work spell may be different from other cycles. It is usually desirable to chart a typical cycle.

d. By better material containers or chucks
Can a smooth motion be used to get parts in and out of containers, chucks, jigs, etc? Use template to check

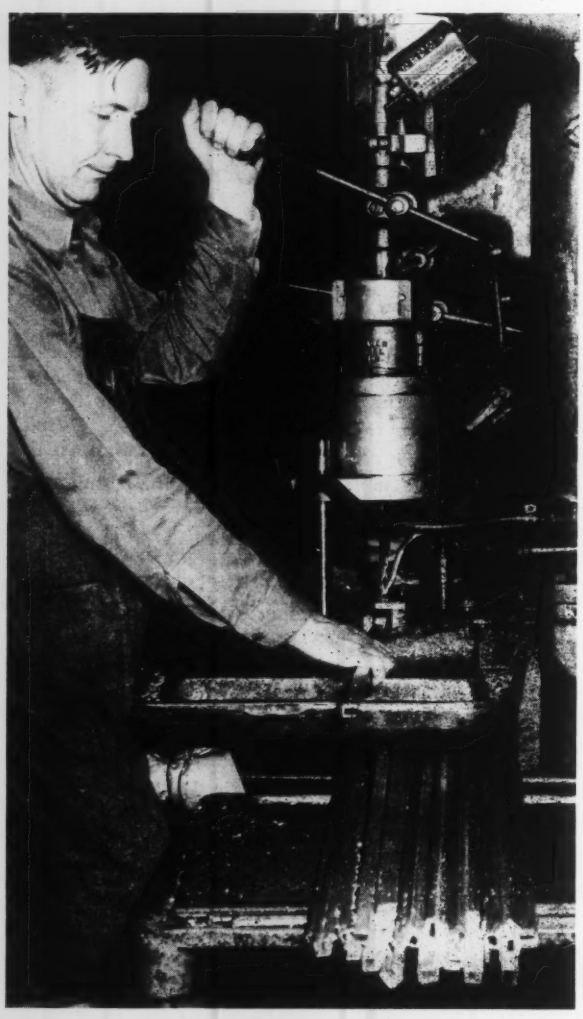
e. By using inertia if possible
Can wheels be weighted to spin rather than be laboriously turned? Use template to check whether heavy parts set in motion may be carried or moved in a relatively straight or smooth line? If wheel is to be spun, is it in convenient position?

f. By using power boosting
Can a control actuate an air or hydraulic cylinder if much force is required rather than be fully manual? Check position for control with human template

g. By lessening visual requirements
Use template to check line of sight and necessary position of the head. Is it comfortable, clear, at a reasonable distance and safe?

h. By better workplace heights
Keep controls such that worker need not stoop or reach too far above his elbow height. Try to keep controls used in sequence at same height, if not combinable. Use template to check observance

Fig. 3—Photograph of original machine and workplace



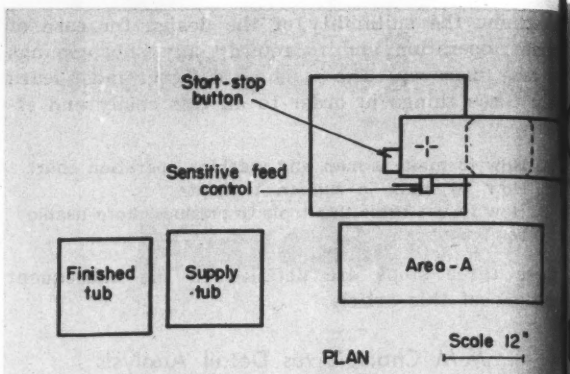
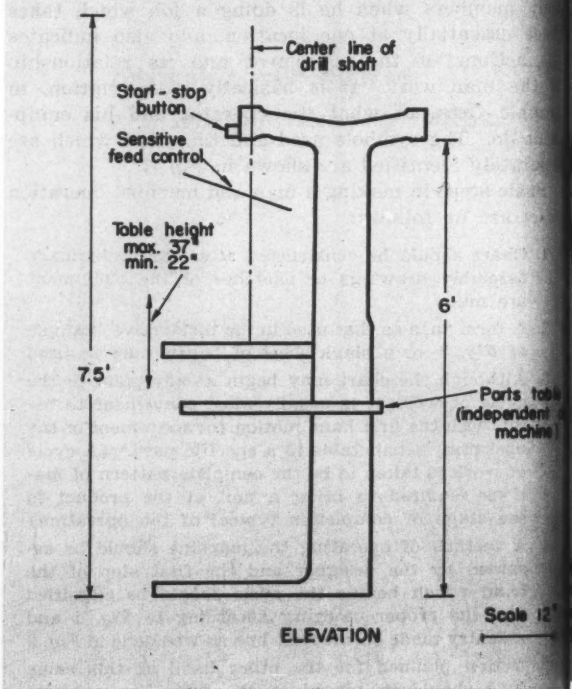


Fig. 4—Above and Below—Layout drawings of special drill setup and associated equipment



of normal work area by the operator.

i. By increasing safety
Use template to check whether worker stays in safe area.

3. Can a movement be eliminated?

a. As unnecessary
Change location of controls, material, etc.

b. By a change in the sequence of operation

c. By combining controls

d. Can material be air ejected, dropped or mechanically removed?

4. Can a movement be made easier?

a. By a change in location of controls, material, etc. Relocate to shorten distance. Use template to check

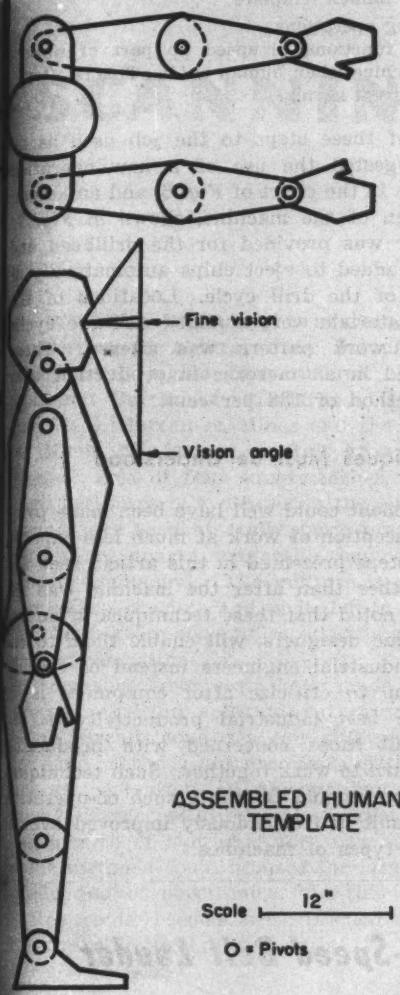


Fig. 6—Man and machine operation chart of improved method over that in Fig. 2

Type of Chart MAN-MACHINE OPERATION CHART
Method IMPROVED
Operation DRILL
Machine No. D-16 A
Operation No. 3
Part Name DOOR HINGE CHANNEL
Part No. 2614-17
Operator C. NEWCOME
Chart by H. AUXFORD
Date Charted 2-49

QUAN	LEFT HAND DESC.	SYMBOLS	RIGHT HAND DESC.
1/PIECE 20 TIMES	FOR RIGHT HAND*		MACHINE
	TO CHANNEL IN FIXTURE		TO SUPPLY TUB
	REMOVE FROM FIXTURE		PICK UP CHANNEL
	TO TABLE		TO FIXTURE
	TURN END & PLACE		PLACE IN FIXTURE
1/20 PIECES 1 TIME	TO AREA A		IN FIXTURE (FOOT ADVANCES DRILL)
	PICK UP 20 CHANNELS		TO AREA A
	TO AREA B		PICK UP 20 CHANNELS
	PLACE 20 CHANNELS		TO AREA B
1/PIECE 20 TIMES	FOR RIGHT HAND		PLACE 20 CHANNELS
	TO CHANNEL IN FIXTURE		TO AREA B
	REMOVE FROM FIXTURE		PICK UP CHANNEL
	TO FINISHED TUB		TO FIXTURE
	PLACE IN TUB		PLACE IN FIXTURE
			IN FIXTURE (FOOT ADVANCES DRILL)

SUMMARY AND RECAP PER PIECE

	IMPROVED L.H.	IMPROVED R.H.	IMPROVED BOTH	ORIGINAL BOTH	SAVED BOTH
○	4.1	4.1	8.2	20	11.8
○	4.1	4.1	8.2	6	-2.2
▽	0	2	2.0	4	2.0
▽	2	0	2.0	12	10.0
TOTAL	10.2	10.2	20.4	4.2	21.6

* DELAY CAUSED BY RIGHT HAND

5—Human templet used for testing designs. A printed copy of the parts required for an articulated templet a 1 inch to 1 foot scale, suitable for cutting out and using, may be obtained without charge by writing to the hor on your company letterhead. Upper body data from Alford, L. P., Production Handbook, Ronald Press, N. Y., 7, p. 591; Eye data from Moon and Spencer, Lighting Design, Addison-Wesley Press, Cambridge, Mass., 1948

b. By changing direction of movements
Use template to check direction. Easiest when counterbalanced by other body member or body

c. By using different muscle groups
Shift location of controls, materials or tools to use the first muscle group in this list that is strong enough for the task:

1. Finger (not desirable for heavy loads)
2. Wrist
3. Forearm
4. Upper arm
5. Trunk or legs (use template to determine probable muscle group used)

d. By making controls and their location, and locations of materials, such that movements may be smooth and continuous rather than jerky. Check with human template and draw flow path of hand

e. By changing from body to arm motions
Examine positions of all controls and materials in respect to human template and attempt to so locate them as to avoid having the operator under the necessity of moving from his work station. See if he can be allowed to alternate at sitting or standing. Controls must be centralized for this.

5. Can a hold be eliminated? (Holding is extremely fatiguing)

a. As unnecessary

b. By an air fixture or power feed.

6. Can a hold be made easier?

a. By shortening its duration
Check speed of air clamps and chucks

b. By using stronger muscles
Foot-operated vises for instance. Use human tem-

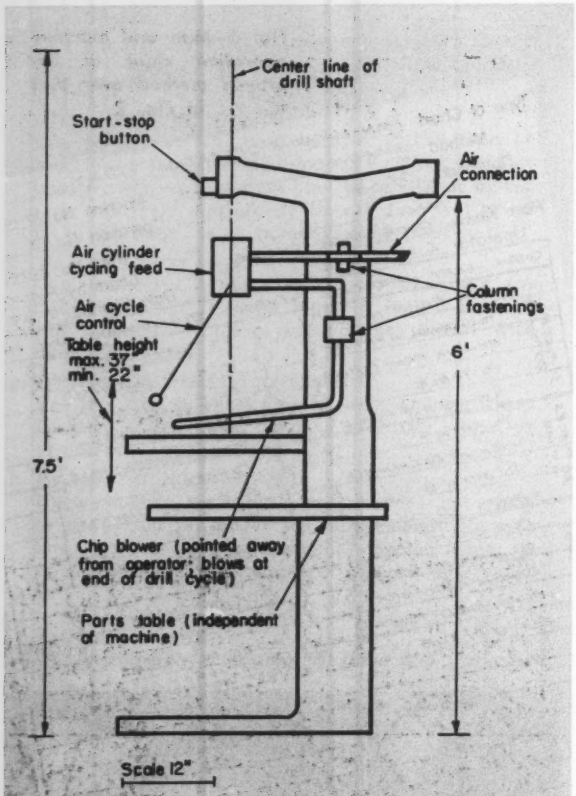


Fig. 7—Drawing of improved equipment. Production increase of 138 per cent resulted

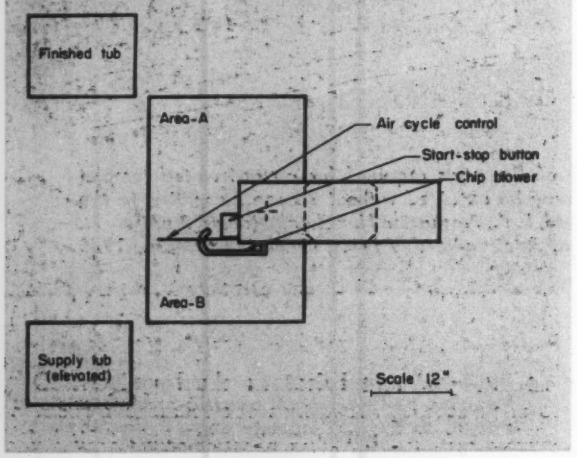


plate to locate proper position relative to work preceding and following use of foot.

7. Can a delay be eliminated or shortened?

a. As unnecessary
Can other work be conveniently done at this point such as get or set aside material? Use template to ascertain whether it is within convenient range of operator

b. By a change of some of the work to the other hand or foot
Move controls etc., to most convenient position as indicated by human template

c. By combining operations
Consolidate functions to speed up part of work done by machine when human is idle. This is often a source of great saving.

Application of these steps to the job used as an illustration suggested the use of a new operation sequence, shown in the chart of *Fig.* 6, and an accompanying redesign of the machine, shown in *Fig.* 7. An air cylinder was provided for the drillhead and an air jet was added to eject chips automatically at the conclusion of the drill cycle. Locations of the controls and materials were changed and the cyclic nature of the work pattern was altered. These changes resulted in an increase in production over the original method of 138 per cent.

Techniques Must Be Understood

This improvement could well have been made prior to the actual inception of work at much less expense had the three steps presented in this article been applied before rather than after the machine was set up. It is to be noted that these techniques, if understood by machine designers, will enable them to co-operate with industrial engineers instead of forcing the latter group to criticize after equipment is in operation. The best industrial productivity is obtained when all those concerned with production effectiveness learn to work together. Such techniques as presented here should facilitate such co-operative activity and result in tremendously improved overall designs for all types of machines.

High-Speed Belt Loader

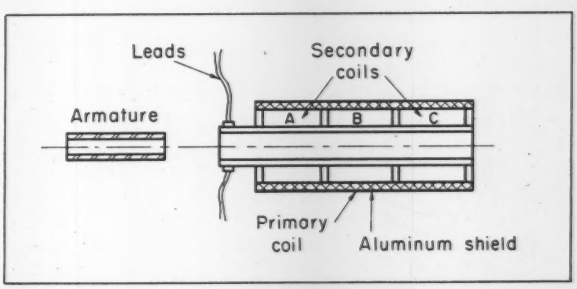
AN INTERESTING conveyor belt application is shown on the Euclid loader in the accompanying illustration. Endless conveyor belts 54 inches wide are used to load 13-yd bottom dump trucks. A 200-hp diesel engine mounted on the loader drives the belt at the head pulley, loading 16 cu yds into the trucks in about 30 or 35 seconds. Operator of the tractor controls starting and stopping of the conveyor unit as each dump truck is filled and a new one moved into place.

SCANNING the Field For Ideas

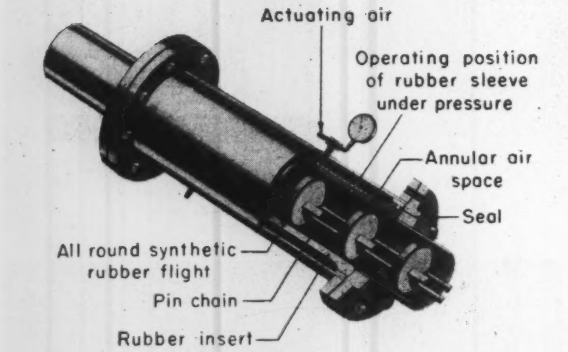
Synthetic mica, right, has essentially the same properties as natural mica but is able to withstand much higher temperatures. Produced at the National Bureau of Standards in co-operation with the U. S. Bureau of Mines and the Colorado School of Mines, the largest crystals grown so far have a surface area of four square inches. To avoid using high pressures in synthesizing the mica, fluorine compounds are used at atmospheric pressure. Raw materials are quartz, magnesite, bauxite, and a fluorosilicate compound. The mixture is placed in a platinum-lined crucible and melted in a 1400 C furnace. As the mixture cools, mica crystals grow from a tiny seed at the bottom.

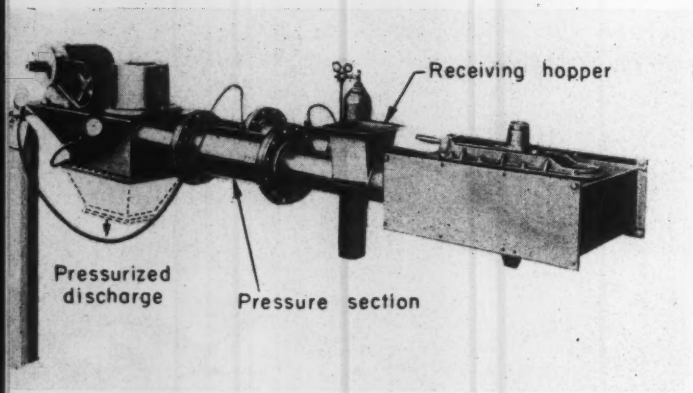
Increasing labor costs have made unprofitable the process of hand splitting natural mica into sheet. Some foreign countries can still process it cheaply by hand methods but producers in the United States are concentrating on the production of half-trim mica. If successful control of crystal orientation in the growth of synthetic mica can be developed, machine methods could be used for large scale domestic production of sheet mica. In this way the United States could become self-sufficient with respect to this valuable insulating material.

Mechanical displacements may be measured electrically with the differential transformer shown schematically, right below. When the armature of the transformer is displaced in either direction, induced voltages in the instrument vary linearly with the displacement. Three coils are wound on a single spool inside of which is the free moving armature. Alternating current is supplied to the center or primary coil, generating a magnetic flux. This flux is distributed by the armature, inducing voltages in secondary coils on each side of the primary coil. With the secondary coils connected in series bucking relationship, there is no voltage output if the armature is centered. If it moves to the left, voltage in the left coil increases. Movement to the right increases the voltage in the other coil. Movement may be indicated on a calibrated voltmeter, recorded on a chart or transmitted by a servo. Designed by Automatic Temperature Control Co., the transformer exerts a negligible reaction force on the transmitting device and has been used with bourdon tubes, bellows, diaphragms, floats, and thermostats.



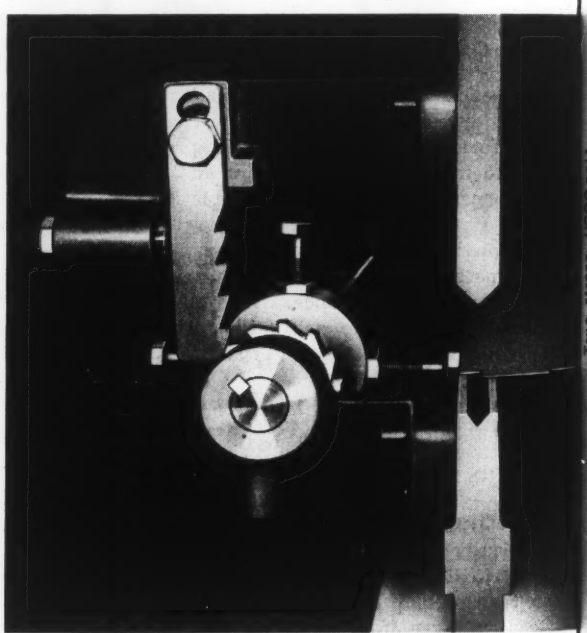
When cooling is required, water is employed instead of air to contract the inner sleeve and to serve as a heat transfer medium. For temperatures above the range of rubber, silastic material is employed. The conveyor drive sprocket assembly at the discharge end of the feeder is maintained at the pressure of the process.





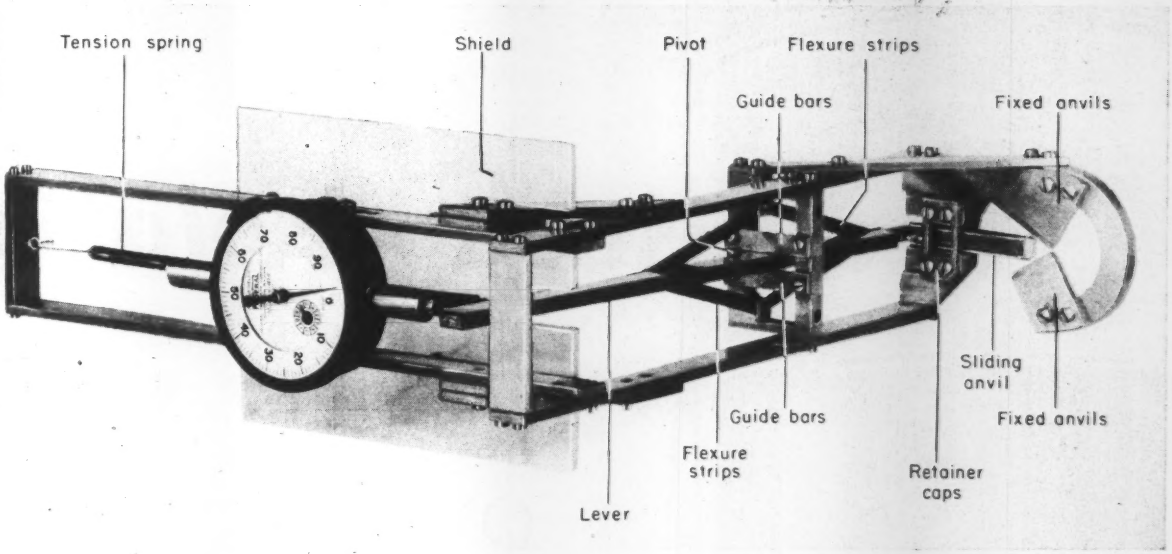
Conveying bulk material into a pressurized or vacuum chamber for continuous processing is effected with chain conveyors having pressure holding sections shown above. On a feeding conveyor, two pressure sections are employed, one on the feed and one on the return to make a closed circuit. For a conveyor discharging from a pressurized chamber, two pressure sections are also utilized. Designed by Hapman Conveyors Inc., the pressure section has a flexible-rubber inner sleeve, making an airtight space between it and the outer casing. Air pressure in this space contracts the inner sleeve to produce a snug fit with the chain flights as they pass through, effecting a sliding seal and holding the pressure in the conveyor beyond the sleeve. The flights are solid construction with pin chains between as shown in the cutaway view.

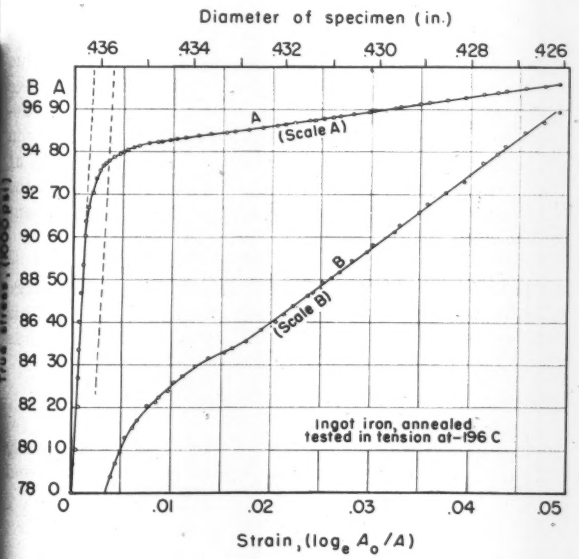
Self-indexing gage, below, provides for four different bends in a press brake. This rotary type gage has a gear rack on a bracket attached to the brake punch which engages a gear on each successive upstroke, indexing the gage to the stop position required for the bend. For repetitive bends the rack is disengaged, making a single-stop gage. The stops are adjustable both as to depth of setting and gage length in this unit designed by General Gas Light Co.



Gage shown top of next page accurately measures the change in diameter of a tensile test specimen. Developed at the National Bureau of Standards for making true stress-strain tests at temperatures between −196 and +100 C, the instrument measures accurately to 0.0001-inch when calibrated against an optical comparator. The maximum deviation of any measured point on the true stress-strain curves corresponds to a change in diameter of less than 0.0001-inch, indicating the accuracy of the instrument.

In the gage, one sliding and two fixed anvils are connected through a lever mechanism to a dial gage. The anvils are SAE 52100 steel and the lever and pivot knife edge are AISI 440C stainless, heat treated



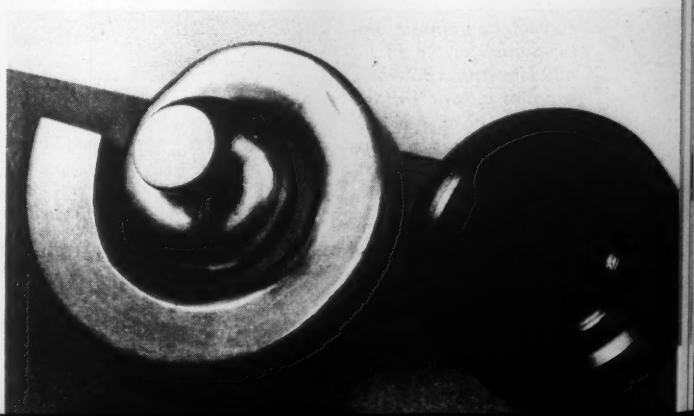


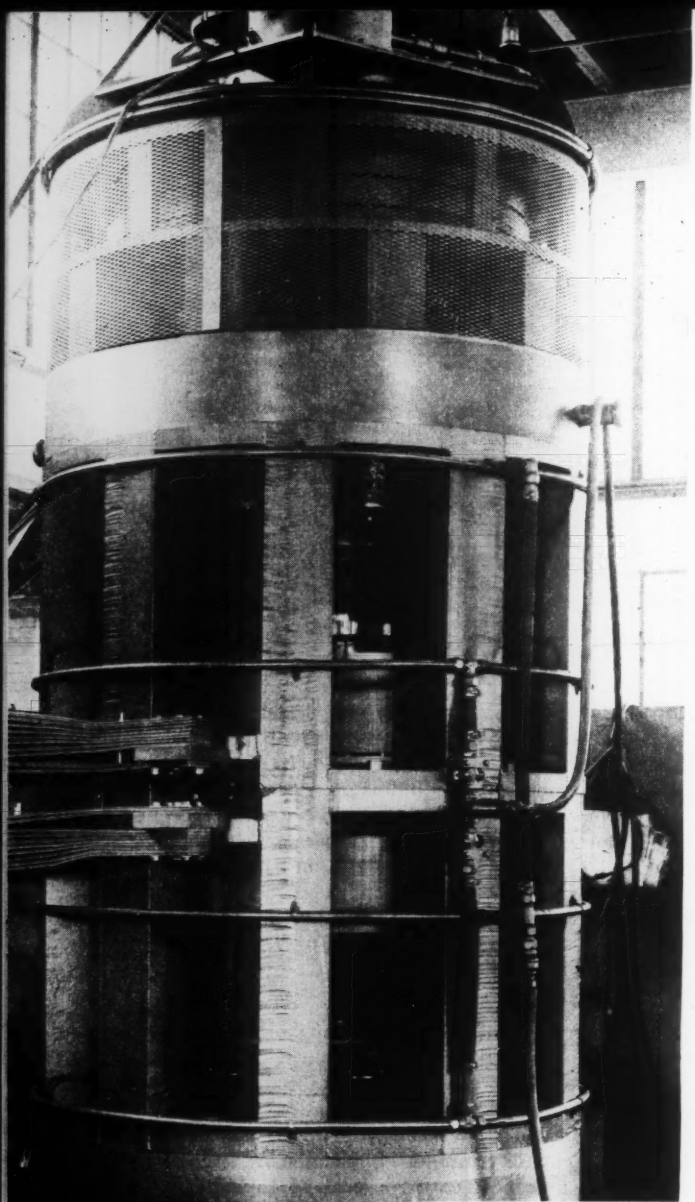
to Rockwell C63 and C55, respectively. The framework is cold-rolled monel.

Change in diameter of the test specimen is followed by the sliding anvil held against the specimen with slight pressure from a tension spring. Movement of the anvil is transmitted to the dial indicator by a simple lever having a knife edge pivot. Four flexure strips maintain the lever in position. The sliding anvil is attached to the lever arm with a small tension spring to facilitate installation of the gage on the specimen. Six ribs on the anvil serve as bearing surfaces. Both ends of this anvil and the contact ends of the fixed anvils have a dihedral angle of 50 degrees and a radius of 0.02-inch.

At an angle of 60 degrees with the fixed anvils, the sliding anvil moves 1.5 times the change in diameter of the specimen. Length of the lever arm between the pivot and anvil is approximately 2½ inches, and the length between the pivot and dial indicator is about 5 inches, making the total magnification of the lever and anvil system three times. In use, about fifteen minutes are allowed for the gage to reach temperature equilibrium. When moved up and down over the gage length of the test specimen the diameter at minimum cross section is easily determined. Alignment of the axis of the instrument with the specimen at any point is determined by minimum reading.

Bladeless pump designed by Fairbanks-Morse employs centrifugal action of a spiral passage in its impeller instead of conventional blades. This enables it to handle liquids containing large solids or fibrous materials and to operate with increased efficiency within its capacity range. Shown below are an impeller and a typical core for casting to indicate the path of flow through the impeller. The pump is capable of handling fibrous material ten to twenty-five times that which a conventional unit will handle. For a specific solid size, a bladeless pump has one-half the capacity of the required conventional pump, providing more efficient operation where flows are relatively low.





Isolating

. . . FROM

ONE of the major problems encountered during the development of the homopolar motor-generator shown in *Fig.* 1 was the design of bearing assemblies to withstand the loads imposed by the rotating element and to isolate the bearings from stray magnetic flux induced by the fields. Due to other elements of the design and application, the generator—rated at 400 kw and 18.7 volts—is designed as a vertical unit to run at 1200 rpm. Driven by a 600-horsepower synchronous motor mounted at the top of the unit, it is connected to the motor through an adapter ring to assure proper alignment of bearings.

Weighing 18,000 pounds, the rotating element is supported entirely by a pedestal carrying a large spherical roller thrust bearing, *Figs.* 2 and 3. This bearing is well adapted to carry the load and has

Fig. 3—Right — Lower bearing assembly showing oil circulation, water cooling and method of electrical shielding

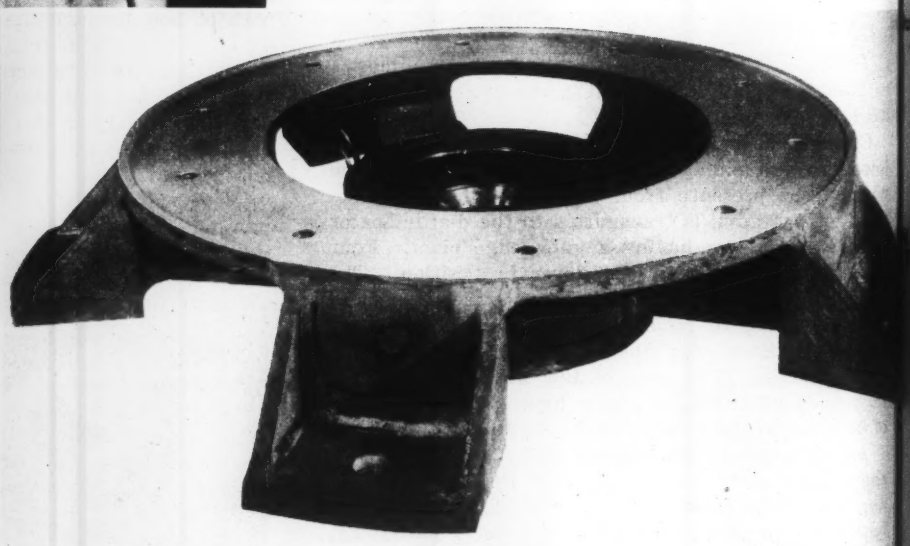


Fig. 1—Above—Direct-current homopolar motor-generator, rated 400 kilowatts 18.7 volts, supplies power for the magnets of a synchro-cyclotron for nuclear research projects

Fig. 2 — Right — Aluminum alloy pedestal base showing the bearing housing

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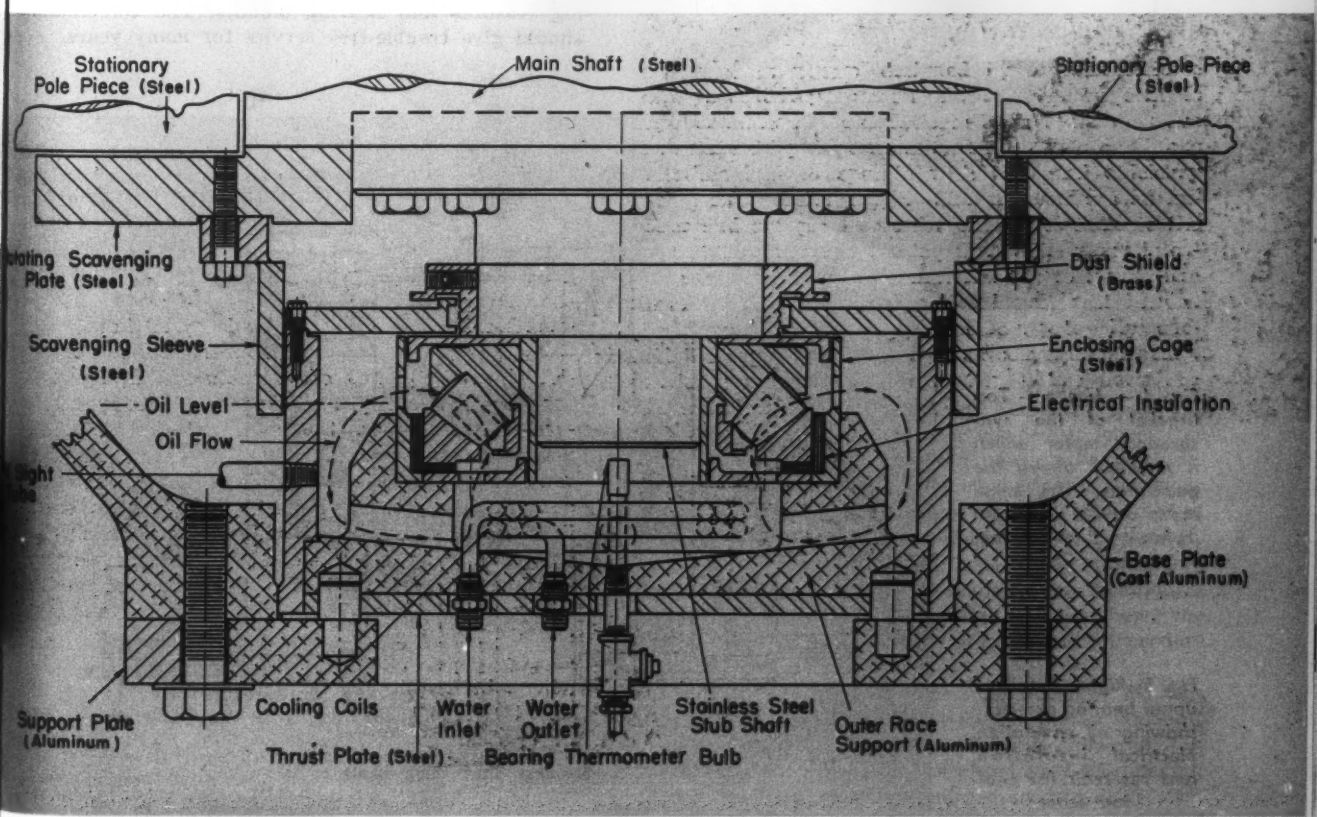
...generator Bearings

...TRAY MAGNETIC FLUX

sufficient radial capacity to eliminate the need of a lower guide bearing. The upper bearing bracket *Fig.* 4, is mounted at the extreme top of the unit and contains a double-row, self-aligning spherical roller bearing, *Fig.* 5, of sufficient capacity to take an approximate radial load of 8000 pounds due to unbalance and air-gap loadings.

Inasmuch as the shaft carries the magnetic flux from the pole face to the armature punchings, considerable flux strays from the shaft and must be diverted from the bearings or they too may become homopolar generators by cutting this flux. This would cause roller failures in the bearings after a short period of operation. Each of the bearings is mounted on a stainless steel stub shaft, carefully machined and fitted to the main flux carrying shaft.

Since the lower bearing is mounted close to the magnetic field and on a stainless-steel shaft, special means of diverting stray flux are required. This is accomplished by mounting a rotating scavenging plate, *Fig.* 3, at right angles to the magnetic shaft just below the stationary pole piece. By controlling the air gap, stray flux from the center of the magnetic shaft is induced by low reluctance to follow the



path through the scavenging plate and thus is diverted from the bearing.

To further protect the bearing, a revolving steel scavenging sleeve is fastened to the scavenging ring. This provides a path for stray flux in the bearing housing and cover to return to the scavenging ring and into the pole piece. This path is induced again by the use of controlled air gaps. A final diversion is accomplished by mounting the bearing in a steel enclosing cage of revolving and stationary parts, accurately turned and finished, with small air gaps to divert any stray flux which may have penetrated other protective means. Further, the outer race is magnetically insulated from the steel enclosure to prevent detrimental circulating current.

Lubricant Is Water Cooled

Action of the roll retainer is adequate to circulate the oil through the rollers and lubricate the bearings. The oil is cooled by water circulating in coils under the oil level and requires approximately two gallons of water per minute to hold the bearings to 50 C. Oil viscosity of 1500 seconds Saybolt at 100 F was found to be satisfactory for the applications.

Lower bearing and housing are supported in a cast-aluminum base plate, *Fig.* 2, which carries the total weight of the rotating and stationary elements. Here again a nonmagnetic material assists in minimizing the stray magnetic flux. A circuit opening thermostat and relay is mounted in the bearing housing and adjusted so that elevated bearing temperatures would open the incoming power lines and shut the unit down.

The upper bearing, mounted on a stub shaft along with the synchronous motor rotor and slip rings, is supported by the top bracket shown in *Fig.* 4. Outer race of the radial bearing, *Fig.* 5, is electrically insulated from the housing and allows for thermal expansion of the rotating element. It is so far removed from the heavy magnetic fields that no added shielding from stray flux is needed. Chambers in the housing are designed so that the lower one encloses the bearing and the upper one acts as a receiver of hot discharge water from the generator slip rings mounted on the main shaft. This water is introduced into the slip rings through a tube in a hole in the main and stub shaft and discharges around the tube into the receiver above the bearing.

Not a self-circulating oil type, the upper bearing utilizes an oil pump to draw oil from the housing and pass it through a copper tube heat exchanger and flow switch before it is fed to the top of the bearing. The pump passes two gallons of oil per minute and the cooling system requires two gallons per minute to maintain a bearing temperature of 60 C. Oil with a viscosity of 350 seconds Saybolt at 100 F was found to be satisfactory.

The bearings on this machine have been selected to have a life of 200,000 hours under normal operating conditions. This could be determined only after careful analysis and proper design of the flux diverting features and bearing mounts. The combination should give trouble-free service for many years.

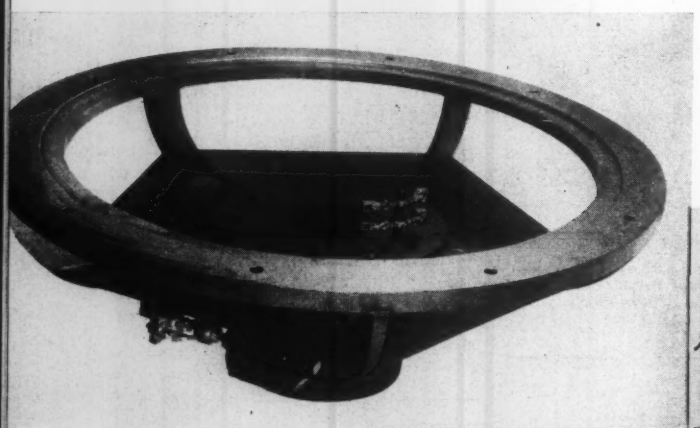


Fig. 4 — Above — Top bracket of the synchronous motor which is mounted above the generator. The small motor-driven pump circulates oil to bearing

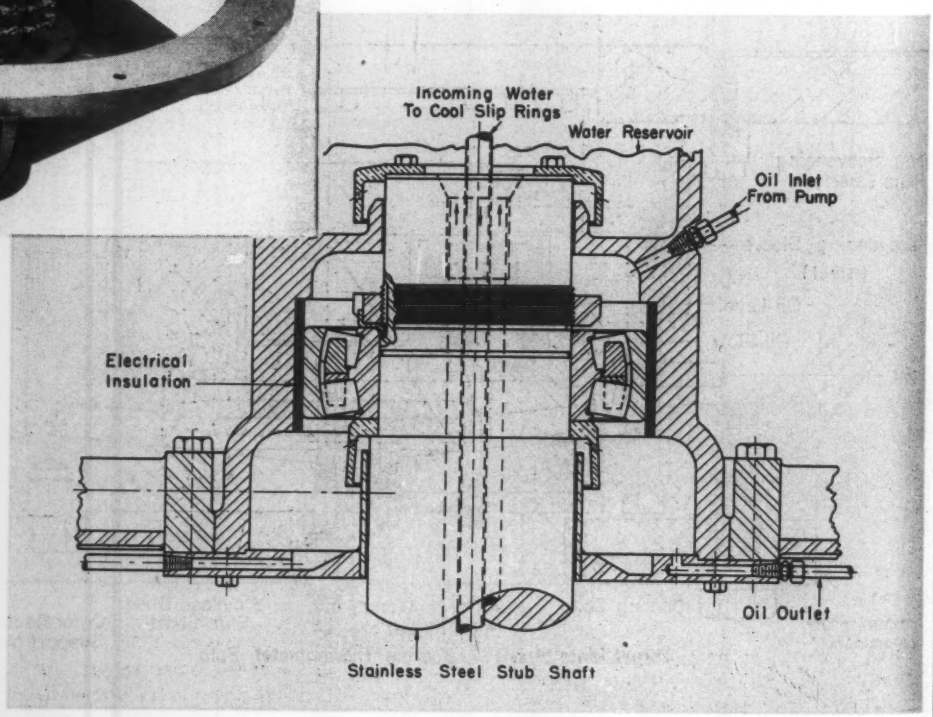
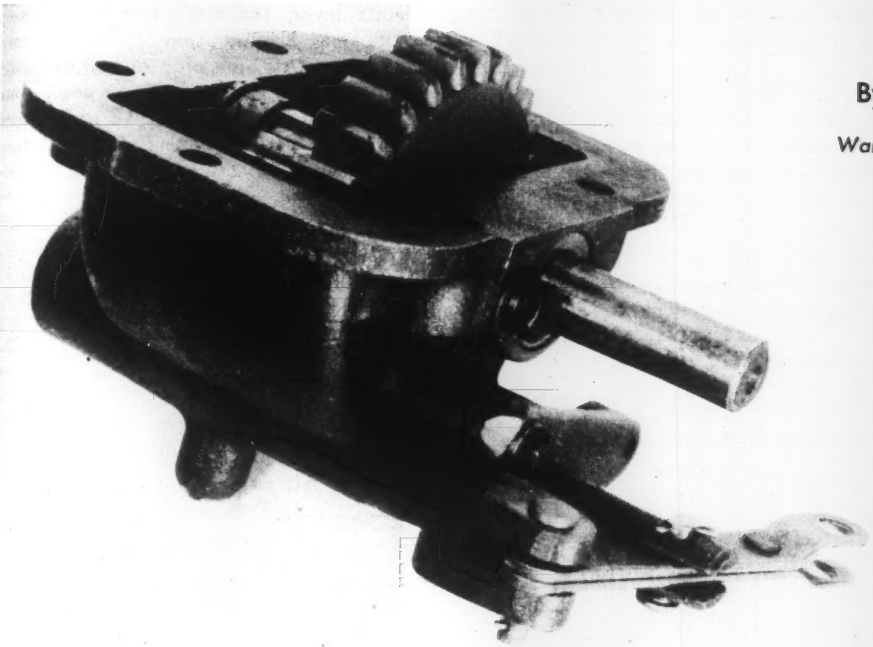


Fig. 5—Right—Details of upper bearing assembly showing oil circulation, electrical insulation, and reservoir for cooling water



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Design for Production

. . . of this power take-off mechanism resulted in unusual savings in labor, materials and maintenance

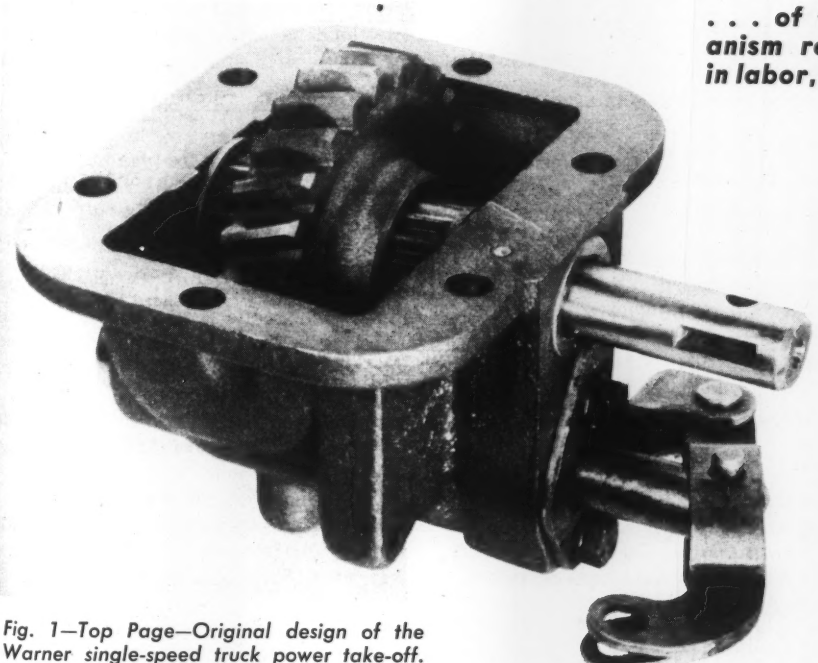


Fig. 1—Top Page—Original design of the Warner single-speed truck power take-off. Design of cast case requires special dry sand cores for producing the undercuts

Fig. 2—Above—Power take-off unit redesign. Draft in one direction permits economical casting in a single green sand mold

TREND of recent years has been to higher manufacturing cost in all products. These increased costs have been reflected in increased selling price to customers. About two years ago it was decided to check the Warner power take-off to determine whether a change in design, material, or method of manufacture, could reduce its cost. All three approaches were made on this mechanism and the results show the value of designing for production.

The old design Warner single-speed power take-off made for most 1½ and 2-ton trucks is shown in *Fig.* 1. These units mount on the standard SAE opening of the truck transmission and are used to drive such

auxiliary equipment as dump mechanisms, tank-truck pumps, tail-gate lifts, wrecker truck hoists, and similar mechanisms.

In this original design, which is similar to competitive products, the oil seal is held in position with a cap screw and washer which required a drilled and tapped hole in the case. A separate casting carries the shift lever and control cable. To accommodate the stamped shift lever, the shift rail had a deep milled slot on the end. Examination of the main case casting reveals undercuts which require two dry sand cores to be made for each casting. These cores were loose pieces which had to be set in the green sand mould. Pattern wear always caused fins and mismatch which required considerable snagging to produce a satisfactory casting.

Fig. 3—Below—Detail drawings showing design of old and new shifter rail. Improved tooling eliminated the need for grinding the extension

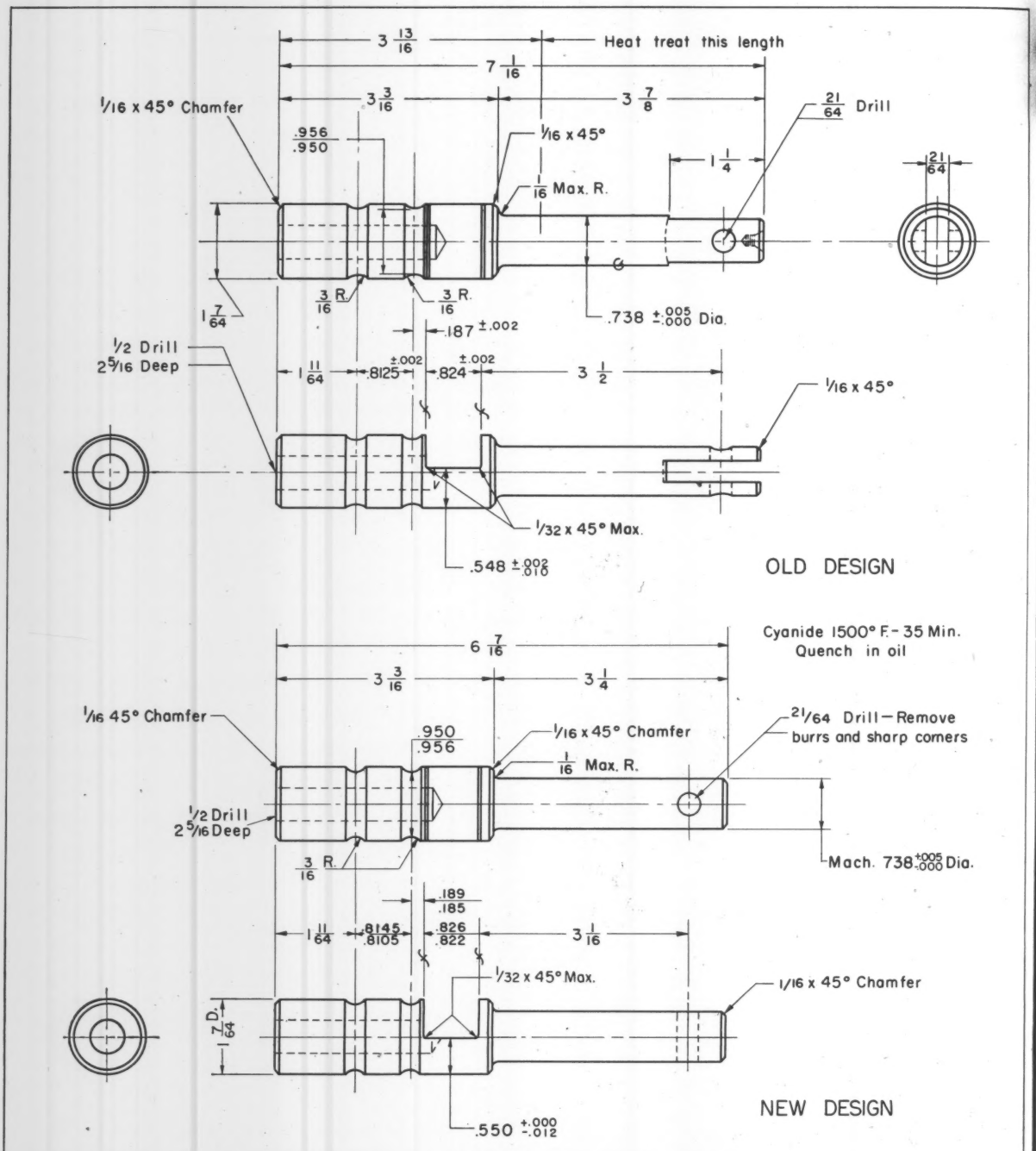


Fig. 4—Cast shift lever bracket and the new improved stamped design which eliminates all machining operations

The shape of the case casting was altered to allow draft in one direction only. Therefore, no loose dry cores were required. Examination of the new case design in *Fig.* 2 reveals a casting which can be made entirely in a green sand mould. Experience in manufacturing the old design with cored holes in the casting indicated greater economy in drilling from the solid.

Cleaning of Casting Important

The primary reason for this is that cored holes less than one inch in diameter are difficult to clean thoroughly of foundry sand and sand wears core drills at an extremely rapid rate. These casting changes allowed a $0.106 reduction in the casting cost. The weight of the new casting is 0.7-lb greater than the old design. This additional weight is more than compensated for by the lower pound price on the casting.

The old shift rail compared to the new rail, *Fig.* 3, shows the elimination of the milled slot. This milling operation cost $0.023 in direct labor.

Cap screw and washer for holding the oil seal, *Fig.* 1, are eliminated by an elongated tab on the new stamped shift lever bracket. Elimination of the cap screw and washer save $0.008 per unit. In *Fig.* 4 the new style stamped shift lever bracket is shown along with the old cast style. The stamping requires no machining operations. The old cast style bracket required four drilling, one slot milling, and one face milling operation. This cast bracket cost $0.057 for the casting alone compared to a cost of $0.034 on the new stamped style. Machining the old bracket cost additional $0.076 in direct labor.

The savings made from design changes are summarized in the following tabulation:

Savings by Redesign	
Case casting	$0.106
Shift rail bracket	0.023
Shift rail	0.023
Elimination of shift bracket machining	0.076
Elimination of cap screw and lock washer	0.008
Total per unit	$0.236

The second phase of this analysis concerned the change of material in the power take-off. The case had always been cast iron. Aluminum was checked and found to be more expensive, so cast iron was specified on the new design. The gear in the old design was made from AISI 8620 material. The new design uses this same material. The new shift rail and old shift rail are of the same material and heat treatment.

The third phase of this analysis concerned the machining of the various parts. Two improvements were made. The new shift rail, *Fig.* 3, was set up with carbide tools and a roller turner on a turret lathe. This roller turner produces such a smooth surface on the 0.738-inch diameter that the grind on this surface was eliminated. The new case, *Fig.* 2, was tooled on a special three-way machine which drills and bores all the holes on three sides at the same time. This operation saves $0.085 in direct labor on the case machining.

Total savings of $0.321 in manufacture are quite attractive and, in addition, the new design has greater eye appeal. The castings are smoother and require very little snagging. The new casting has the same finish texture all over due to the elimination of dry sand cores. The machining operations are more efficient and the accuracy better; drills and tools last longer. The increased tool life and other intangibles are not included in the savings mentioned.

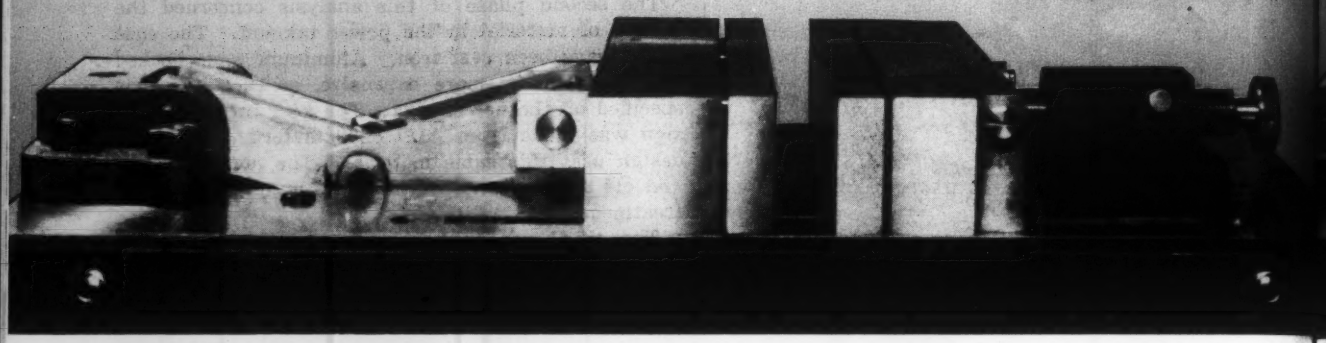
A price reduction on this unit was given our customers early in 1948. This was most unusual at a time when all other prices were still increasing. Warner's profit percentage is the same on the new selling price as on the old higher price. Another redesign is now being considered on this same unit as there are further possibilities for additional savings by design refinements.

They Say...

"A company without a program for technological betterment is a poor risk. The most conservative attitude toward profits today is a policy of deliberate risk-taking. The biggest gamble is to do no research at all"—EDGAR A. JETT II, *assistant director, Armour Research Foundation.*

"The responsibility of an engineer is above and beyond that of producing materials and machines. He also has a definite responsibility to see that the devices he has created are used constructively"—K. B. MCEACHRON, JR. *manager, technical education division, General Electric Co.*

Determining Toggle Ja



TOGGLE joints are most often applied to operations which require large forces and permit short strokes. They may have arms of equal or unequal lengths, and may be either simple or compound linkages. The simple toggle or the primary toggle of the compound linkage may be operated by hydraulic or pneumatic cylinder, screw, cam, solenoid, or lever. The crank-operated toggle joint is a special form of compound toggle joint.

A typical toggle application is the press shown in *Fig.* 1. The cylinder-operated single toggle joint employed has arms of equal length. Being basic, this joint can be used to illustrate the method of predicting the maximum force that can be developed between the jaws of a toggle press.

MECHANICS OF TOGGLE DESIGN: Geometry of the toggle is shown in *Fig.* 2. Relations between the design variables are given by the following equations:

$$\frac{P}{F} = \frac{\cos a}{2}$$

$$X = 2L\ (1 - \cos a)$$

$$H = L \sin a$$

Squeezing force, P, is obtained by multiplying the force ratio, P/F, by the applied force, F, in pounds. The values of X' and H', *Figs.* 3, 4, 5, and 6, are computed for a toggle joint having arms 1-inch long. Therefore, to determine the actual values of X and H, multiply X' and H' by the length of the toggle arm, L, in inches.

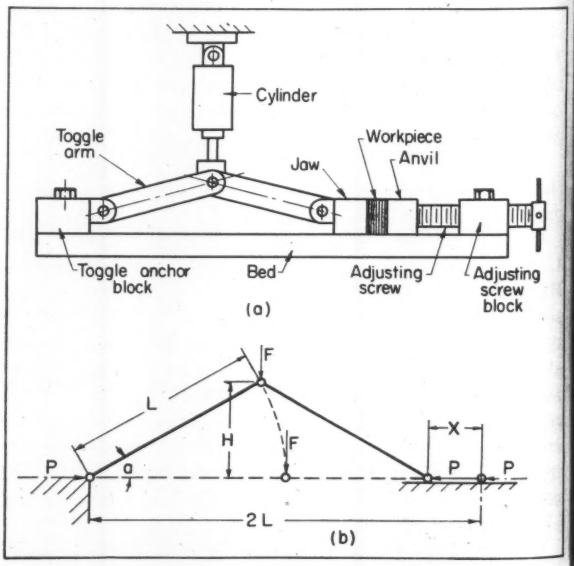
Trigonometric relations of the joint indicate the theoretical possibility of developing an infinitely large force between the jaw and anvil. This possibility is emphasized by plotting P/F vs angle a, *Fig.* 7. Effect of deflection in the frame and workpiece were neglected in plotting *Fig.* 7. Actually, large forces are developed only when the frame and work piece are extremely rigid.

To calculate the greatest possible jaw force, P, it is necessary to compute the rigidity of the frame and workpiece, and to co-ordinate the deflection rate of the frame and workpiece with the force-displacement characteristic of the toggle joint.

The force-displacement characteristic is represented by a P vs X curve developed from *Fig.* 4 for each

Fig. 1—Above—Press employing cylinder-operated single toggle with equal arm lengths

Fig. 2—Schematic diagram of single toggle having equal arm lengths with design variables indicated



Force

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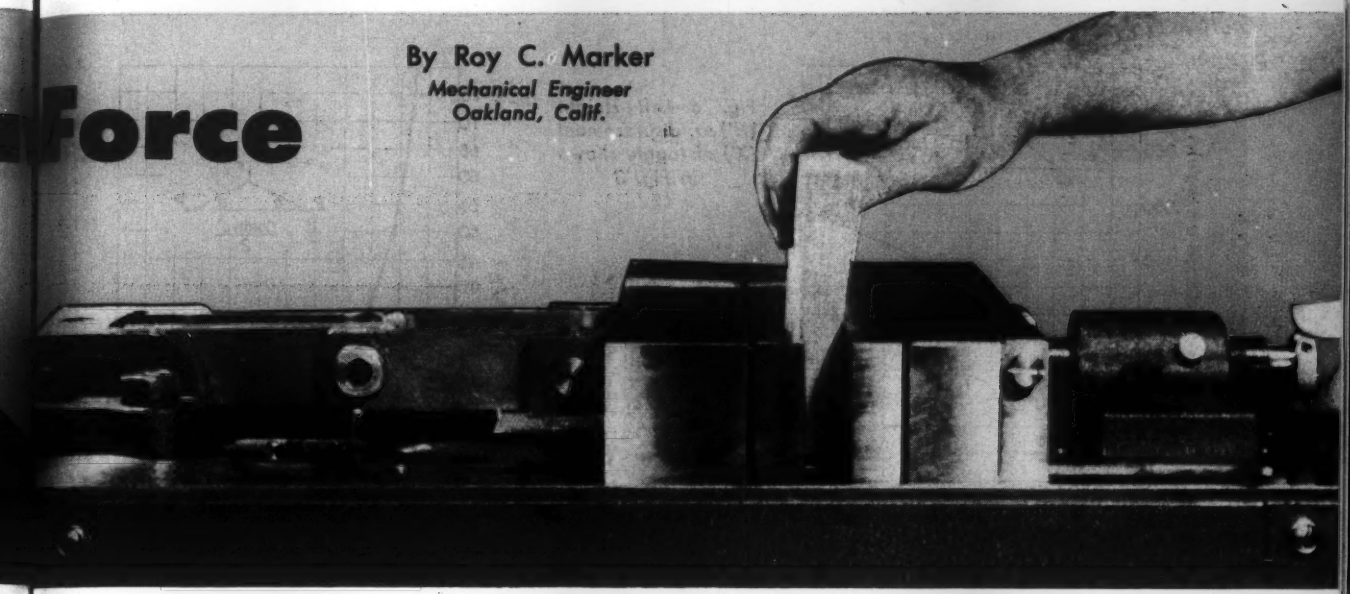


toggle joint by taking into consideration the toggle arm length, L, and the applied force, F.

Deflection rate of the frame and workpiece, referred to as the "frame deflection rate" is calculated by means of the deflection formulas for members loaded in tension and compression, bending, and shear. The frame deflection rate is the sum of deflections of the frame members and workpiece, in inches, which contribute to the distortion of the frame and workpiece at the contacting face between the jaw and workpiece, and may be visualized as a compression of the workpiece plus separation of jaw and anvil. The deflections are calculated for an arbitrary load which can in most cases, be taken as 1000 lb. The frame deflection rate is then expressed in terms of inches per 1000 lb. This distortion of the frame and workpiece (which produces the resistance to the jaw's movement) is graphically represented by a straight line on the P vs X chart developed for the specific toggle joint under consideration, *Fig.* 8. The

Fig. 3—Displacement (X') vs. angle (a) of single toggle having one-inch arms

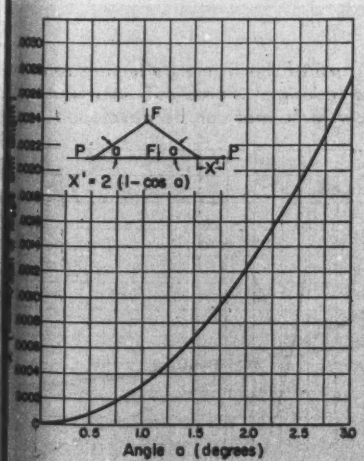


Fig. 4—Force ratio (P/F) vs. displacement (X') of toggle shown in Fig. 3

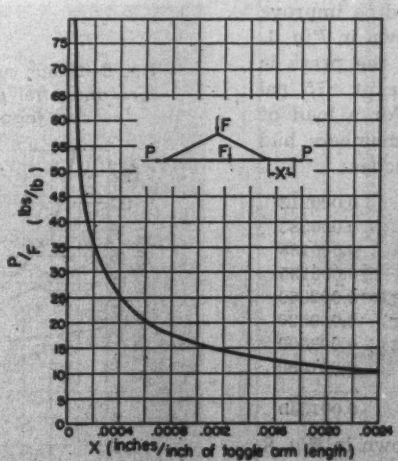
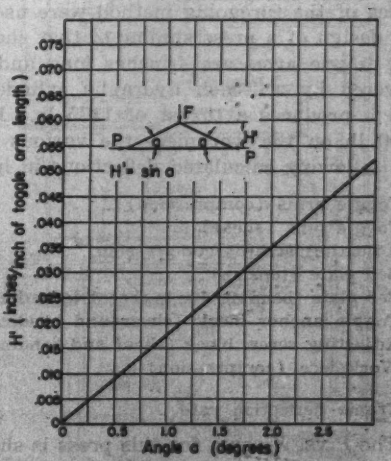


Fig. 5—Height (H') vs. angle (a) of toggle shown in Fig. 3



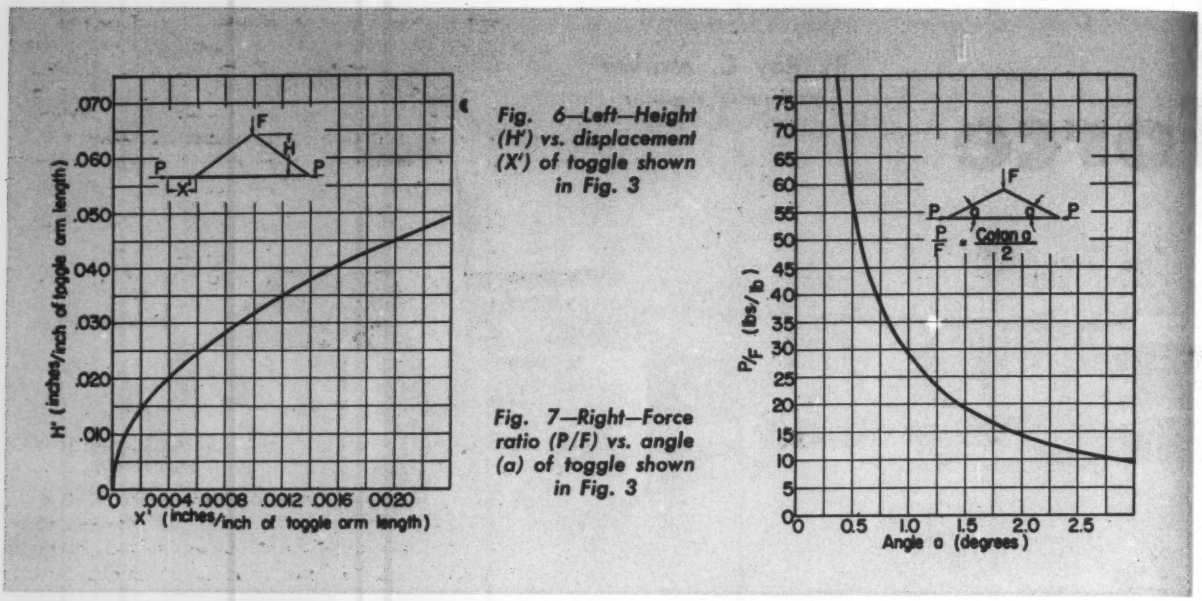


Fig. 6—Left—Height (H') vs. displacement (X') of toggle shown in Fig. 3

Fig. 7—Right—Force ratio (P/F) vs. angle (α) of toggle shown in Fig. 3

slope of the line is equal to the frame deflection rate in inches per 1000 lb.

As the jaw moves forward it engages the workpiece at some point determined by the position of the anvil. In most designs the anvil position is adjustable to provide for differences in workpiece thickness and to obtain the maximum possible jaw force. By increasing the workpiece thickness or advancing the anvil toward the jaw, it is possible to displace a frame deflection rate curve to the right until it intersects the P vs X curve. Under this condition the toggle joint will stall at a value of X equal to that of the lower intercept and exert a correspondingly reduced force. Thus, for optimum results when the press is used for quantity production, the anvil should be adjusted so that the maximum plus tolerance in the workpiece thickness will not cause the toggle joint to stall at any point short of its complete stroke.

TOGGLE MECHANICS APPLIED TO PRESS DESIGN: Principles of the foregoing method were used to improve the design of a press similar to that shown in *Fig.* 1. The toggle arms are 4-inches long and the press is powered by a 2-inch hydraulic cylinder at 375 psi which produces a thrust of 1175 lb. For a load of 1000 lb on the workpiece the various members had the following calculated deflections in inches:

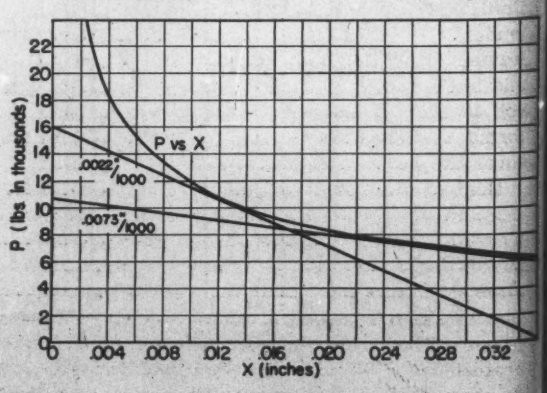
Toggle arms (compression)	0.000213
Toggle pins (shear)	0.000283
Adjusting screw (compression)	0.000138
Bed plate (tension)	0.000135
Bed plate (bending due to eccentric loading)	0.002060
Toggle anchor block (shear and bending)	0.000520
Adjusting screw block (shear and bending)	0.003000
Workpiece (compression)	0.001000
Frame deflection rate	0.007349

The P vs. X chart for this press is shown in *Fig.* 8. The frame deflection rate of 0.0073 inches per 1000 lb is also shown on the chart, and its intersection with the vertical axis indicates that the maximum force, P, equals 10,700 lb. To increase P, the bedplate was redesigned with heavier ribs, and the adjusting screw block was more securely anchored. The frame deflection rate decreased to 0.0022 inches per 1000 lb as a result of stiffening the bed and block, and the maximum force, P, increased to 16,000 lb. It should be noted that the squeezing force, P, was increased 50 per cent without changing the linkage or size of cylinder.

DESIGN PROCEDURE WHEN CYLINDER FORCE VARIES: If the applied force, F, is not constant throughout the entire stroke then it is necessary to construct a P vs X curve in the following manner:

1. Plot a F vs H curve as determined by the operating characteristics of driving mechanism
2. Construct P/F vs X and X vs H curves for the toggle joint using *Figs.* 4 and 5

Fig. 8—Linear curves are of the frame deflection rates before and after press redesign. Force axis intercepts indicate toggle jaw force that can be developed



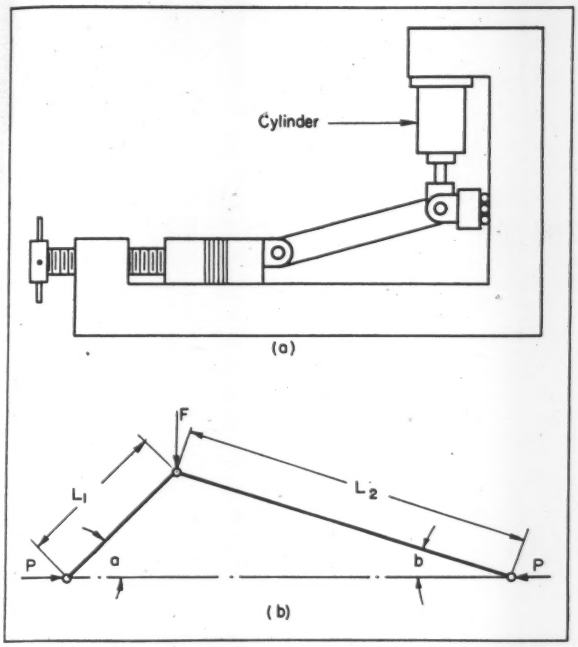


Fig. 9—Diagram of toggle having unequal arm lengths

3. Select several values of X from the X vs H curve and determine the corresponding values of H and F from the X vs H and F vs H curves
4. Multiply the values of P/F and F corresponding to the same value of X and plot this product as a function of X. This is the P vs X curve for the toggle joint when powered by a variable force, F, and is used in exactly the same manner as described earlier for the toggle joint driven by a constant force.

In some situations a toggle joint having unequal arms may be of value. Such a toggle joint is shown schematically in *Fig.* 9. The geometry of this toggle indicates the following relations:

$$\frac{P}{F} = \frac{1}{(\tan a + \tan b)}$$

$$X = L_1 (1 - \cos a) + L_2 (1 - \cos b)$$

Thus, if $L_1 = L_2$, then $a = b$ and consequently $P/F = (\cot a)/2$ and $X = 2L\ (1-\cos a)$. However, if L_2 is made infinite in length, then angle b is zero, $P/F = \cot a$, and $X = L\ (1-\cos a)$. These results indicate that the toggle joint shown in *Fig.* 9, which is equivalent to having one arm, L_2, of infinite length, exerts twice the theoretical jaw force, P, and has one-half the jaw movement, X of a toggle joint having two arms of equal length.

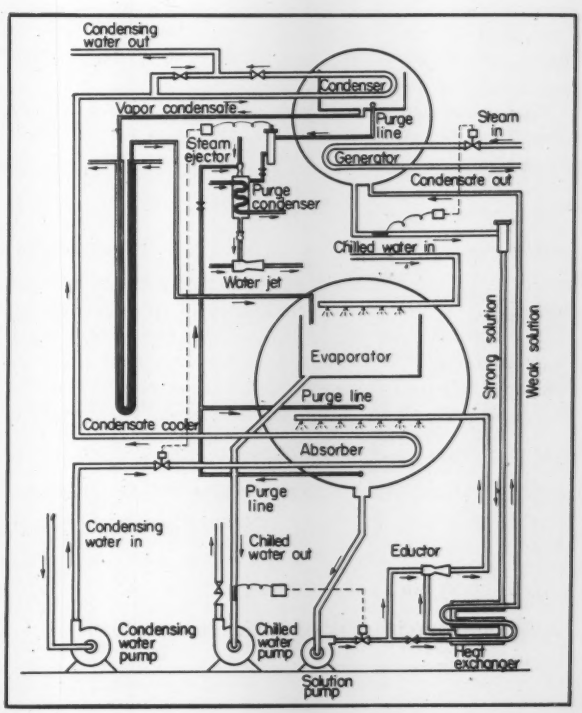
Friction in the various joints and between the sliding parts has been neglected in this analysis; however, it is usually found to have a negligible effect on the output of the toggle joint, particularly when angle a is small.

Refrigeration System Operates On Water

AN absorption refrigerating machine that uses plain water as a refrigerant and a simple salt as an absorbent operates at double the efficiency of ammonia machines and represents a lower initial capital investment.

The working cycle of the unit, made by Carrier Corp., is as follows: Water to be chilled is sprayed into a flash evaporator located in the upper portion of the absorber-cooler shell. Since this shell is maintained at a high vacuum, a portion of the chilled water evaporates and cools the remaining water. Chilled water drains from the cooler tank, and is pumped to the load. Temperature of the chilled water leaving the machine depends on the concentration and temperature of the salt solution sprayed over the coil located in the lower portion of the shell which forms the absorber section. The salt solution absorbs the water vapor flashed in the evaporator.

Heat of absorption of this vapor tends to raise the temperature of the solution, which is therefore cooled by water passing through the absorber coil in order to maintain the solution at a proper temperature. The absorption of water vapor reduces the salt concentration of the solution, thus also reducing its absorbing power. Therefore the weak solution is continuously drained from the absorber shell and delivered by the solution pump to the upper shell for re-concentration.



By Paul Grodzinski
Mechanical Engineer
London, England

Bevel Gear Trains

. . . how to calculate shaft angles of intermediate gears

ALTHOUGH a triple bevel gear drive between two shafts at a given angle, *Fig.* 1, can be designed by cut and try methods, a general solution to the problem has not hitherto been available. To remedy this situation the author has evolved the general method presented in this article.

Fig. 1 shows the general problem. Shaft OA can be considered as the driving shaft, and shaft OC as the driven shaft, which include a given angle. Between these shafts another shaft OB is to be included, so that when all shafts are equipped with bevel gears with numbers of teeth N_1, N_2, N_3, a distinct transmission ratio $R = N_1/N_3$ is available which, of course, is independent of the ratio between the gears N_2 to N_1 and N_3. The condition of rolling between the bevel gears requires that the three shafts intersect in one common axis. This is easily understood from the fact that gear N_2 can be considered at first as a part of the gear couple N_1N_2, and further as a part of the second gear couple N_2N_3.

The following relations between the angles can be read from *Fig.* 1:

$$\gamma_1 = \alpha_1 + \alpha_2 \quad \ldots\ldots (1)$$

$$\gamma_2 = \alpha_2 + \alpha_3 \quad \ldots\ldots (2)$$

$$\gamma = \gamma_1 + \gamma_2 \quad \ldots\ldots (3)$$

where γ, γ_1, γ_2, are the included angles of the shafts; and α_1, α_2, α_3 the pitch cone angles of the bevel gears.

The condition of the rolling on the common point O is geometrically represented by the fact that the cone length C is equal for each of the three gears. Taking D_1, D_2 and D_3 as the pitch diameters of the gears,

$$C = D_1/2\sin\alpha_1 = D_2/2\sin\alpha_2 = D_3/2\sin\alpha_3 \quad \ldots\ldots (4)$$

with $D_1 = N_1/P$, $D_2 = N_2/P$ and $D_3 = N_3/P$, the diametral pitch, P, being necessarily equal for all three gears,

$$C/2P = N_1/\sin\alpha_1 = N_2/\sin\alpha_2 = N_3/\sin\alpha_3 \quad \ldots\ldots (5)$$

Equation 5 can be divided in the two relations

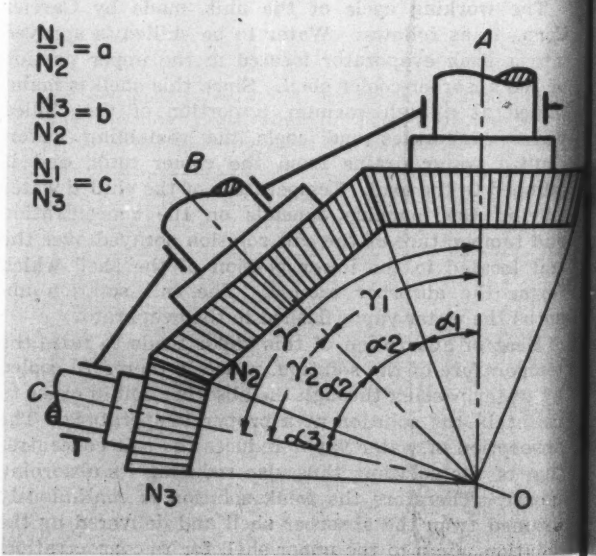
$$\frac{N_1}{N_2} = \frac{\sin\alpha_1}{\sin\alpha_2} \quad \ldots\ldots (6)$$

$$\frac{N_3}{N_2} = \frac{\sin\alpha_3}{\sin\alpha_2} \quad \ldots\ldots (7)$$

With the aid of Equations 1 and 2 and some usual transformations, the known relations for bevel gears with shaft angles other than 90 degrees are obtained:

$$\tan\alpha_2 = \frac{\sin\gamma_1}{\frac{N_1}{N_2} + \cos\gamma_1} \quad \ldots\ldots (8)$$

Fig. 1—A triple bevel gear drive in which the angle between driving and driven shafts (OA) and (OC) is known, and the speed ratio is known; the angles between the idler shaft (OB) and the other shafts are to be determined



$$\tan \alpha_2 = \frac{\sin \gamma_2}{\frac{N_3}{N_2} + \cos \gamma_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

The foregoing two expressions for tan α_2, the pitch cone angle of the intermediate wheel, must be identical, hence

$$\frac{\sin \gamma_1}{\frac{N_1}{N_2} + \cos \gamma_1} = \frac{\sin \gamma_2}{\frac{N_3}{N_2} + \cos \gamma_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Introducing $N_1/N_2 = a$, $N_3/N_2 = b$, and $N_1/N_3 = c = a/b$, that is, $a = bc$, the following main equation, derived in the Appendix, results

$$\frac{\sin \gamma_1}{a + \cos \gamma_1} = \frac{\sin \gamma_2}{b + \cos \gamma_2} = \tan \alpha_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

GRAPHICAL SOLUTION: *Fig.* 2 gives values of the function tan α_2 according to Equation 11, using a with γ_1 and b with γ_2. This main diagram is extended by a diagram representing the sum of co-ordinates, $\gamma_1 + \gamma_2$, for performing the necessary subtraction $\gamma_2 = \gamma - \gamma_1$.

Use of the diagram is shown by the following example: If $\gamma = 90$ degrees, $N_1/N_2 = a = 2$; $N_3/N_2 = b = 0.5$, the values of tan α_2 to be used lie on the curves 2 for a and 0.5 for b. The actual value must be found by trial. Try at first the value $\gamma_1 = 60$ degrees, entering the chart at point *A;* go up to curve 2, and locate the point *B*; then go down to the auxiliary diagram to point *C* on line $\gamma = 90$ degrees, horizontally to point *D* (having thus performed the subtraction $90 - 60 = 30$ degrees), and follow the line for $\gamma = 30$ degrees to point *E,* whence go vertically to point *F* on curve 0.5. If this were the right solution, the points *B* and *F* would be on the same level. This will seldom be the case at the first trial, and usually there is a difference $\Delta = B - F$ or $F - B$. An auxiliary diagram, *Fig.* 3, is constructed to determine the differences for successive values; for instance, for $\gamma_1 = 60$, 65 and 70 degrees, values of Δ are drawn as ordinates on the diagram with the correct positive or negative sign. The values have to be connected by a curve and the intersection point with the horizontal line for $\Delta = 0$ gives the required value γ_1, for which tan α_2, as well as $\gamma - \gamma_1$, has an equal value. The precision of the solution can be further controlled by calculation, and eventually the value obtained graphically can be improved.

The auxiliary diagram forming the lower part of *Fig.* 2 can be omitted, as the simple calculation $\gamma - \gamma_1$ can be made mentally.

GRAPHICAL AND APPROXIMATE SOLUTION: For this

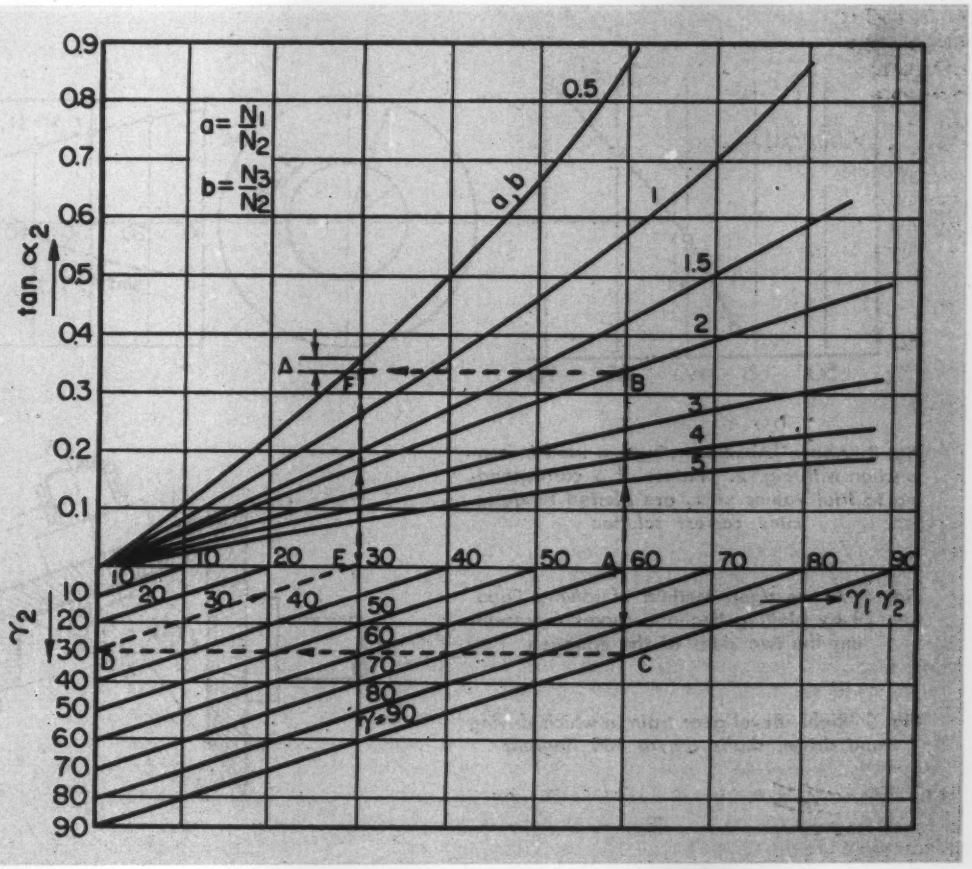


Fig. 2—Chart for determining tan α_2 in Equation 11, where γ_2 is the pitch cone angle of the intermediate bevel gear in Fig. 1

solution the formulas hitherto presented are somewhat changed. Utilizing Equation 11, multiplying and rearranging,

$$b \sin \gamma_1 - a \sin \gamma_2 = \cos \gamma_1 \sin \gamma_2 - \sin \gamma_1 \cos \gamma_2 = -\sin (\gamma_2 - \gamma_1) \quad \ldots\ldots (12)$$

Replacing γ_2 by $\gamma - \gamma_1$,

$$b \sin \gamma_1 - a \sin (\gamma - \gamma_1) = \sin (\gamma - 2\gamma_1) \quad \ldots\ldots (13)$$

Expanding the left-hand side and rearranging,

$$\sin \gamma_1 (b + a \cos \gamma) - (\cos \gamma_1)\, a \sin \gamma = \sin (\gamma - 2\gamma_1) \quad \ldots\ldots (14)$$

It is evident that the left-hand side can be represented as the sine of a difference when the expression $b + a \cos \gamma$ and $a \sin \gamma$ can be brought to a corresponding form. This is made by the substitution

$$r \cos \varepsilon = b + a \cos \gamma \quad \ldots\ldots (15)$$

$$r \sin \varepsilon = a \sin \gamma \quad \ldots\ldots (16)$$

The auxiliary values r and ϵ are determined by the expressions

$$\tan \varepsilon = \frac{a \sin \gamma}{b + a \cos \gamma} \quad \ldots\ldots (17)$$

$$r^2 = a^2 \sin^2 \gamma + (b + a \cos \gamma)^2 \quad \ldots\ldots (18)$$

This substitution brings Equation 14 to the form

$$r \sin (\gamma_1 - \varepsilon) = \sin (\gamma - 2\gamma_1) \quad \ldots\ldots (19)$$

The problem can now be solved by drawing the two sine curves, the common intersection point giving the required value for γ_1. This is illustrated in *Fig. 4*. The curve corresponding to the left-hand side of Equation 19 has amplitude r, phase-difference ϵ, and frequency + 1. The sine-curve corresponding to the right-hand side has amplitude − 1, frequency 2, and phase-difference γ. For the example solved in *Figs. 2* and *3*, substitution in Equations 17 and 18 gives ϵ = 75 degrees 58 minutes approximately, and r = 2.06, γ being 90 degrees.

For practical applications, it is only necessary to design the curves for a distinct interval where the angle can be expected. For this purpose a criterion* is helpful. Since $a = bc$, Equation 13 can be written:

$$b = \frac{\sin (\gamma - 2\gamma_1}{\sin \gamma_1 - c \sin (\gamma - \gamma_1)} \quad \ldots\ldots (20)$$

As the value b can be assumed to be always positive and greater than 0, its value cannot be below 0; letting the numerator = 0, therefore, $\gamma_1 > (\gamma/2)$. On the other hand, if the denominator is 0, b will become infinite; also, this case is impossible.

In the second case,

$$\sin \gamma_1 = c \sin (\gamma - \gamma_1) = c \sin \gamma \cos \gamma_1 - c \sin \gamma_1 \cos \gamma \quad \ldots\ldots (21)$$

(*Concluded on Page* 180)

* The author is indebted to Werner Bloch for proposing this solution.

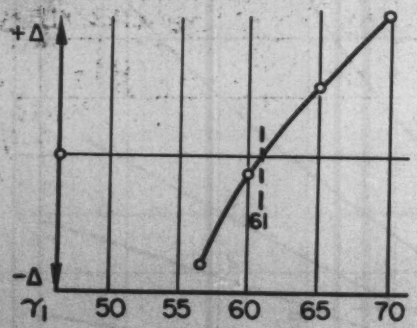


Fig. 3—Above—Auxiliary diagram used in conjunction with Fig. 2. Values of Δ corresponding to trial values of γ_1 are plotted to determine correct solution

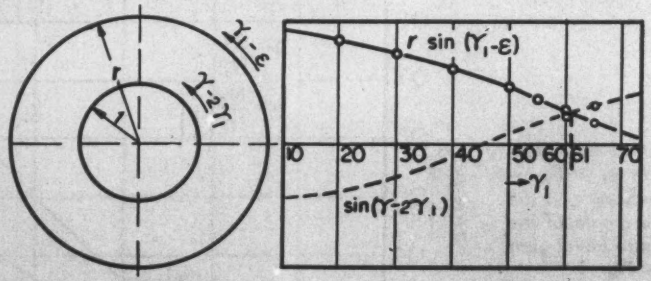


Fig. 4—Above right—Method of solving Equation 19 by plotting two sine curves representing the two sides of the equation

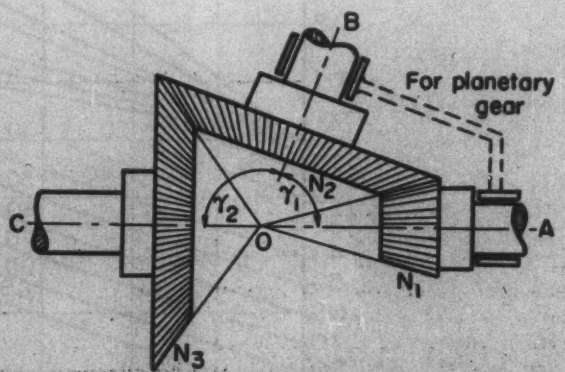
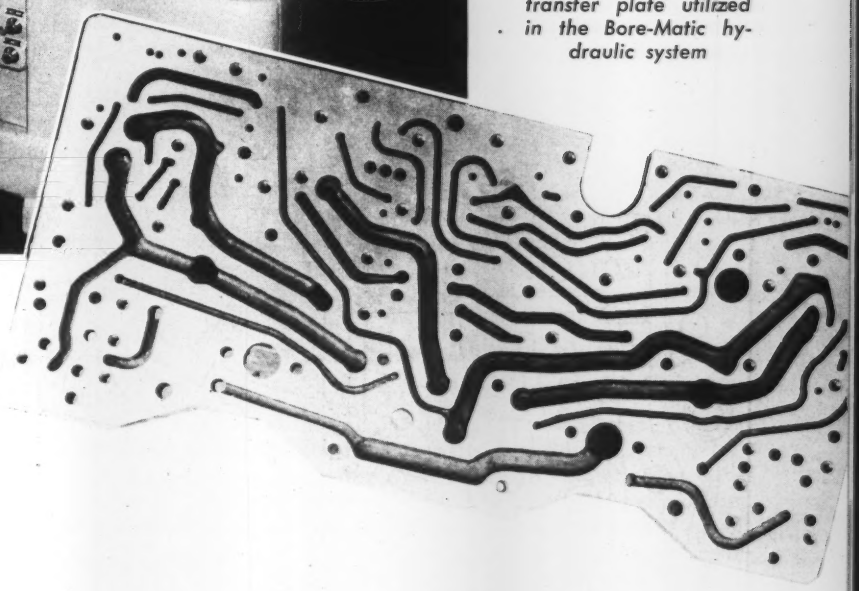


Fig. 5—Right—Bevel gear train in which driving and driven shafts are at 180 degrees

Fig. 1—Left — A typical Heald Bore-Matic precision borer which embodies a complex hydraulic system for automatic cycling

Fig. 2—Below — Cored transfer plate utilized in the Bore-Matic hydraulic system



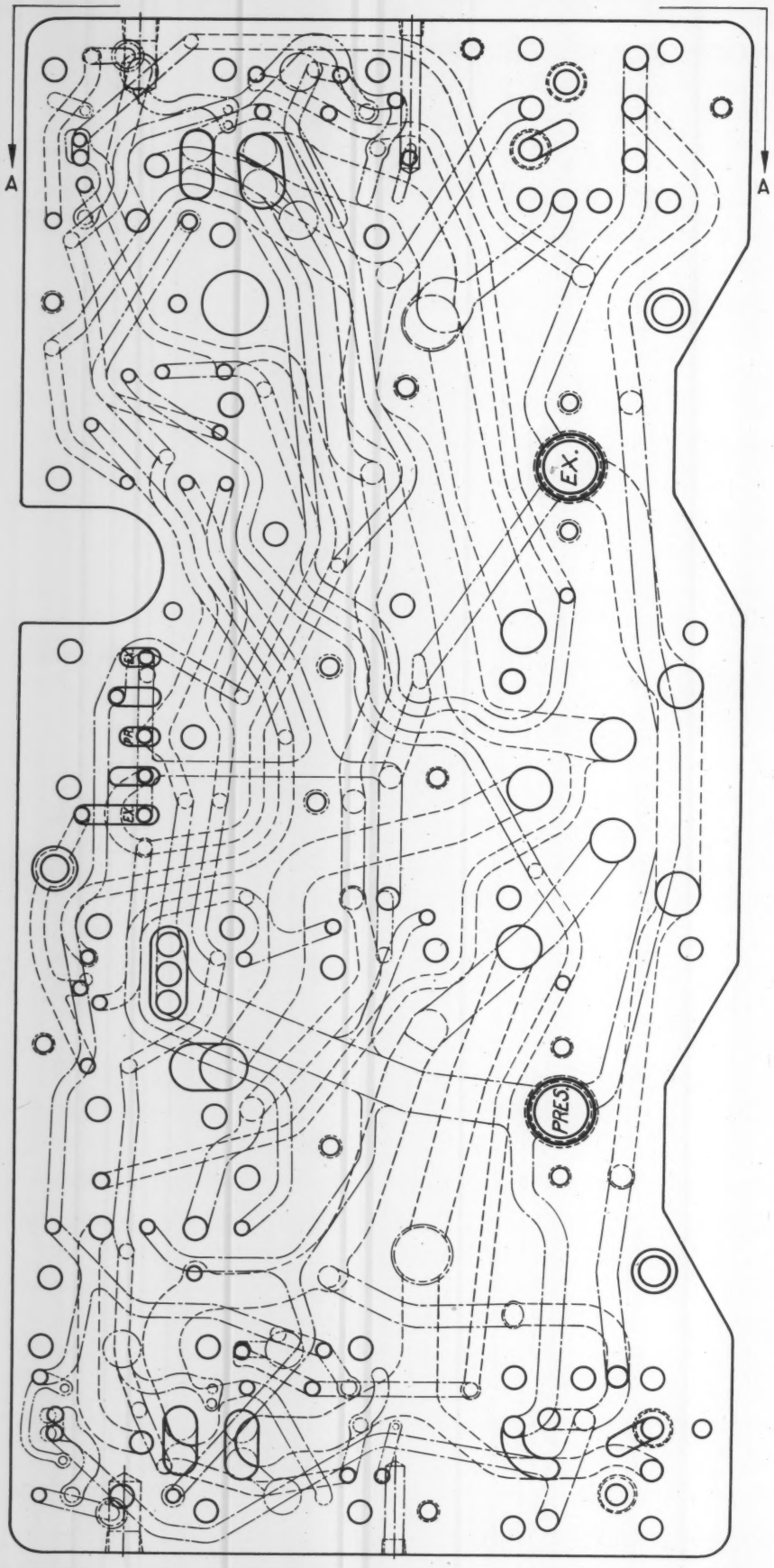
By P. H. Warren, Jr.
The Heald Machine Company
Worcester, Mass.

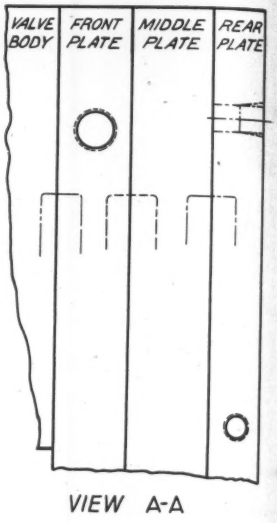
Transfer Plates

. . . simplify complex hydraulic installations

SUCCESSFUL application of hydraulic power to operate machinery depends to a large extent on the method by which the fluid is transferred from its source to and from the different control units and valves involved. This, of course, is extremely important in the case of precision machine tools, *Fig.* 1, and similar equipment which is hydraulically actuated.

There are three basic ways of accomplishing the transfer of a hydraulic pressure medium. First and probably most common, is to effect hydraulic fluid transfer between valves by piping. This presents numerous difficulties because of the large number of connections required for even the simplest of circuits necessary to provide a variety of cycles for a given standard machine. Second, all control valve units may be housed in a single body. This involves extremely complex porting and drilling, makes the





VIEW A-A

valves inaccessible and the body housing so large that a greater machine base cavity must be provided, thus often weakening the strength characteristics of the machine itself. Third, transfer plates housing all the complex control circuits in a panel may be used. The Heald Machine Company makes wide use of this later method in their new line of Bore-Matics, internal and surface grinding machines, *Fig.* 2.

Hydraulic transfer plates actually are not new but recent refinements and developments have placed them in a category of unusual value and economy where precision hydraulic control is a necessity. Fundamentally speaking, these transfer plates are cast with cored passages and are bolted together in a double or triple layer to provide the desired manifold arrangement. To the front of the first plate are bolted the various valve units which direct and control the flow of the hydraulic fluid. An intricate honey-combed nerve center for hydraulic circuits is the result of this construction, *Fig.* 3.

The manufacture of these plates presents a number of interesting casting and ma-

Fig. 3—Drawing of a triple transfer plate showing the complex arrangement of circuits obtained in a minimum of space

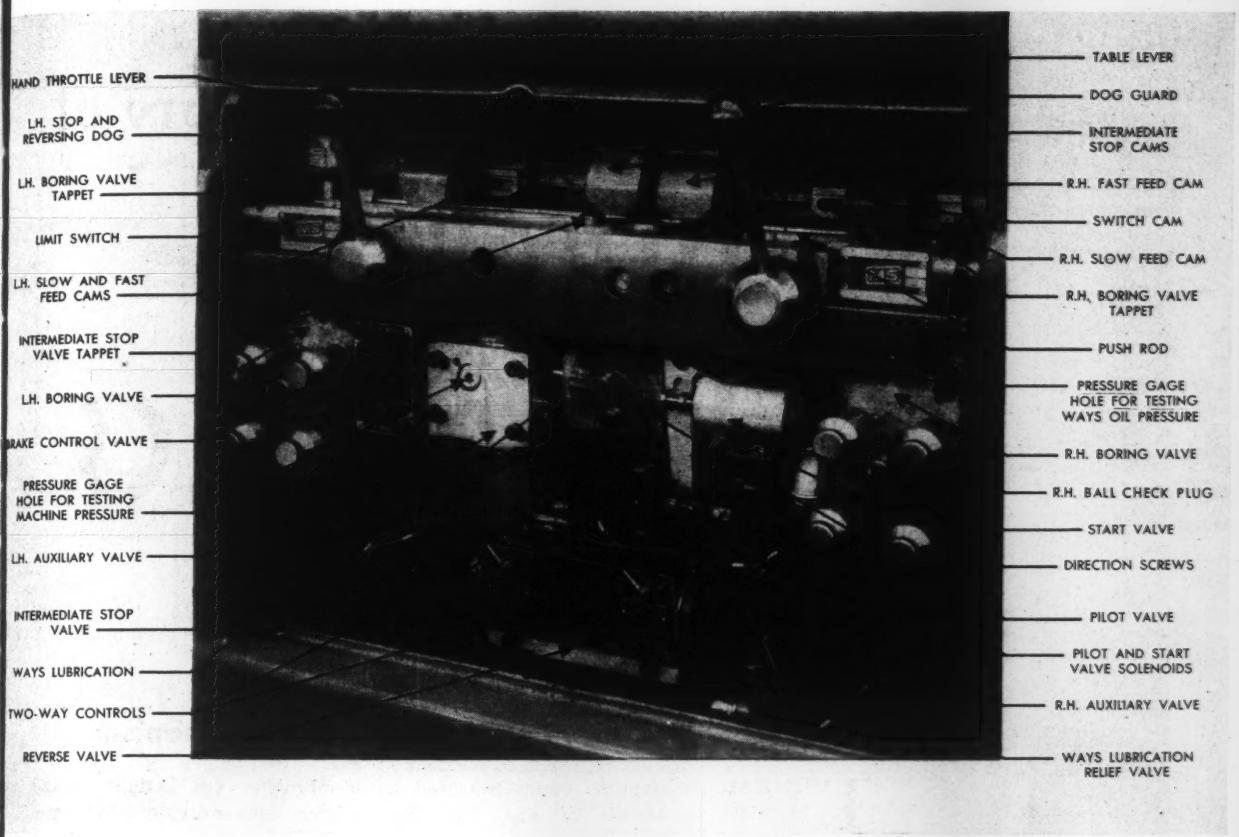


Fig. 4—View into machine showing transfer plates with valves and controls installed

chining problems. Extra large risers are cast with each plate. These risers provide a heavy mass of slow cooling metal which helps to prevent shrinkage and provides a means of absorbing casting impurities which might adversely affect the structure of the plates. After casting, the cored passages in the plate are burred and shot blasted to provide a smooth track for the oil, free from sand, ridges, etc. The plate is then milled off to rough size.

Before the plates are drilled and tapped, a transparent Lucite platen or master locates three master holes and the plate is turned over and double checked for correct alignment; from these holes the drill jig is located. Next comes surface grinding to an accuracy which will permit no leakage when the plates are bolted together—no gasket is used. The finish grind is held to a total parallelism tolerance of 0.001-inch with a good "commercial" surface finish. The faces are not lapped. Obviously surface grinding this type of casting presents the problem of an interrupted cut no matter which way the part is turned. Consequently none but a free cutting grinding wheel can perform the job properly. Careful inspection between each of these steps prevents needless scrap.

Assembly of the transfer plates is by means of numerous screws properly spaced. Actually, the three-plate unit, *Fig.* 3, is fastened with some seventy screws resulting in a degree of tightness which insures perfect operation of the machine.

Likewise, no seals are utilized in mounting the valves on the front plate. The maximum pressure permissible with this arrangement for satisfactory service has never been completely determined. Most machines are operated at from 100 to 150 psi pressure. Some systems employ a 400 psi pressure and on one particular machine a peak load of 900 psi is encountered for a short period, the pressure dropping back to the 400 psi average pressure for the remainder of the machine cycle.

Several features of the transfer plate present real advantages to the ultimate user. By providing a compact unit which utilizes the shortest distances for hydraulic fluid travel, giving the minimum pressure drop, the precision uniformity of feed so desirable in a machine is obtained. Greater accuracy and production are achieved and all adjustments to compensate for viscosity changes are eliminated. Furthermore, a transfer plate just can't get out of order, leakage is negligible and yards of bulky piping are unnecessary. Valve units are conveniently located on the front of the plate. Each is held individually by four screws and is easily removable for service attention if necessary, *Fig.* 4.

The universality of the transfer plate makes the application of a wide variety of cycles an easy matter by additions or exchange of valve units or by eliminating unnecessary functions by means of cover plates. Machine functions on both single and double-end equipment are equally well controlled by this versatile device.

Highlights in the History of MACHINE HYDRAULICS

By H. G. Conway
Technical Director
British Messier Ltd.
Gloucester, England

Part 5—Impulse Pumps and a Pump Mechanism

THE RAM or impulse pump invented by Montgolfier (of balloon fame) in 1796 is shown in *Fig.* 12. The original inventor of the ram pump, it appears, was the Englishman Whitehurst in 1772, Montgolfier being responsible for the automatic ball valve improvement. Montgolfier was, however, unaware of the earlier development and deserves full credit for a remarkable invention. To use Ewbank's words (1842), "The device by which Montgolfier made the ram self-acting is one of the neatest imaginable. It is unique: there never was anything like it in practical hydraulics or in the whole range of the arts." The modern hydraulic engineer will not dispute this opinion.

Action of the ram is as follows: Water descends the pipe *B* from a source *A* which must be at a high level. The water escapes out of the valve *E* and the momentum of the water will increase. When the velocity through *E* has increased sufficiently the ball will be lifted and will shut the exit suddenly. The momentum of the water is then dissipated by entering the air vessel at *D* through a flap valve. The air inside *D* is compressed and subsequently expands forcing the water up the pipe at *F*. By correctly adjusting the weight and size of the ball, a continuous cycle of operations can be obtained and water can be pumped to a very high level.

In order to eliminate trouble with the dissolution of the air at *D* into the water (a difficulty which was appreciated by Montgolfier), an alternative system was proposed as shown in the upper diagram in the illustration. This had an additional valve at *B* (subsequently called a "snifting" valve) which drew in a small amount of air each time the pressure wave was reflected and created momentarily a suction. This allowed a small and continuous bleed of air to enter to keep the air vessel full enough.

The ball valve device is what is now called a hydraulic fuse.

The great city fires of the seventeenth and eighteenth centuries gave considerable stimulus to the design of improved fire pumps and efficient pump mechanisms. *Fig.* 13 illustrates a lever pump used by Newsham on his famous fire engine pump in London in 1730-40. This is worth reproducing to show the ingenious sector and strap mechanism. It will be noted that there are two (or three) straps on each piston rod, tensioned tightly on the sector wheel. This mechanism is rare if known at all today. Making use of spring steel strip it could probably find wider application, as a substitute without blacklash, for a rack and pinion.

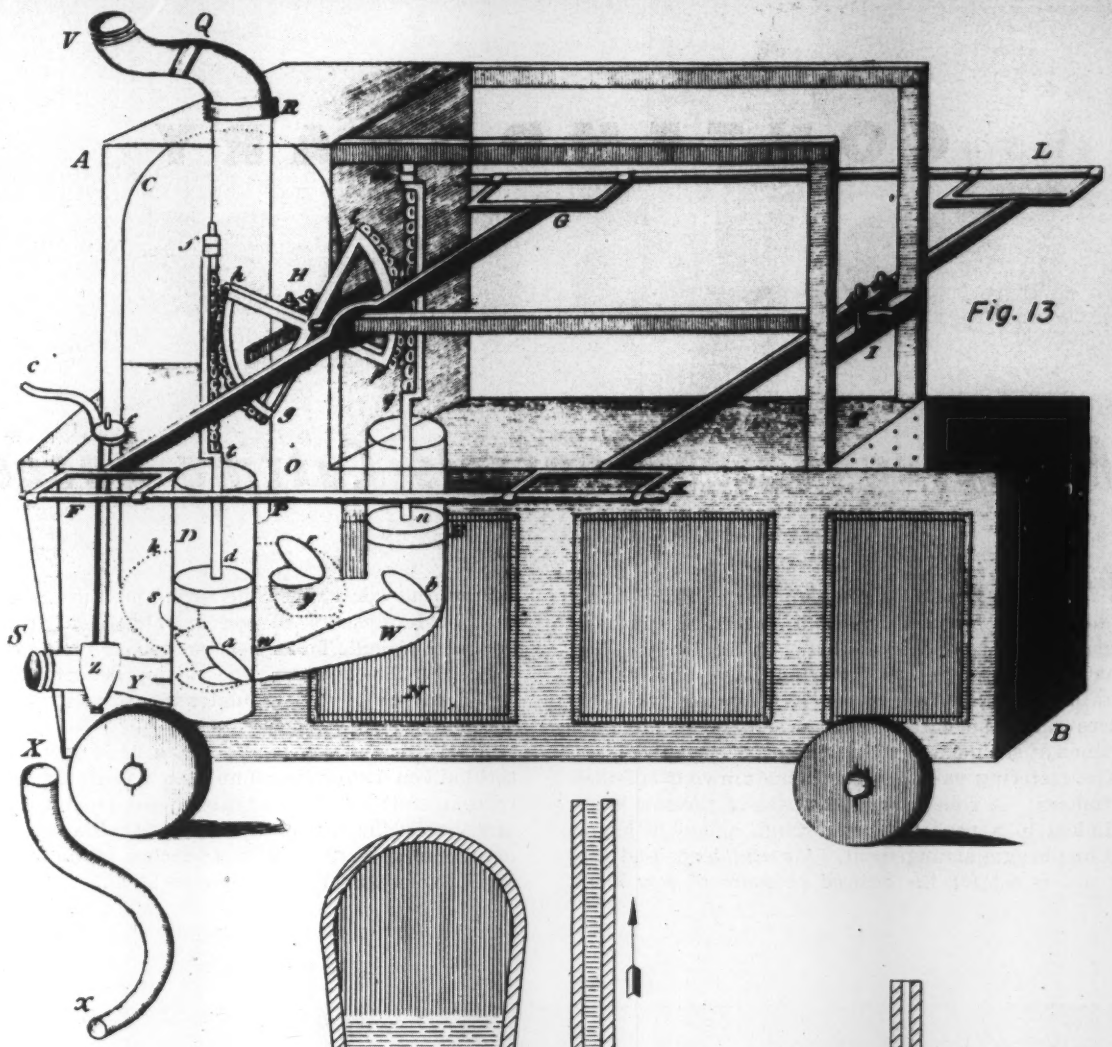


Fig. 13

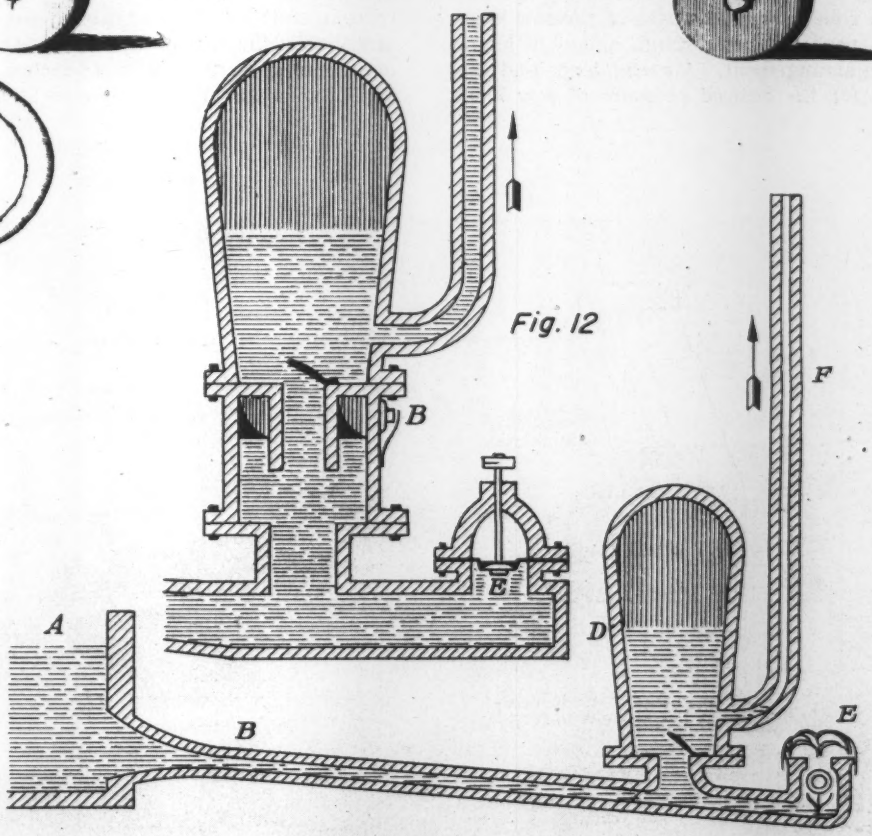


Fig. 12

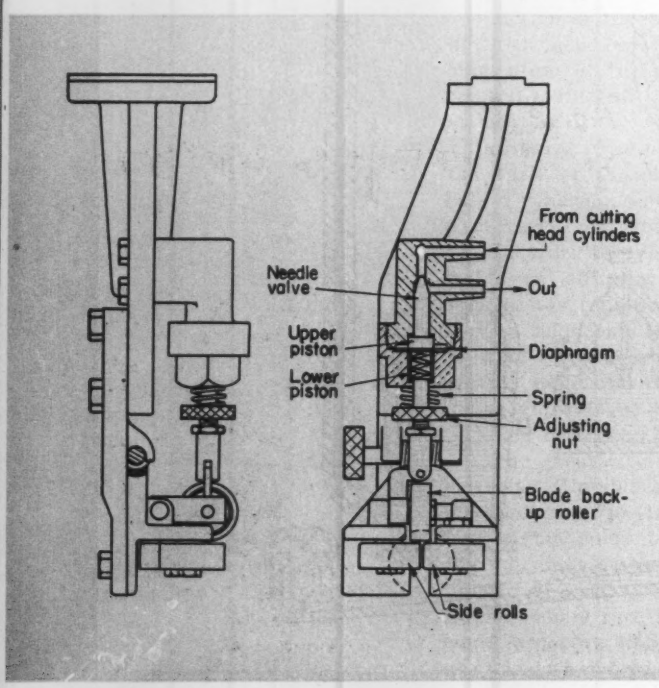
CONTEMPORARY DESIGN

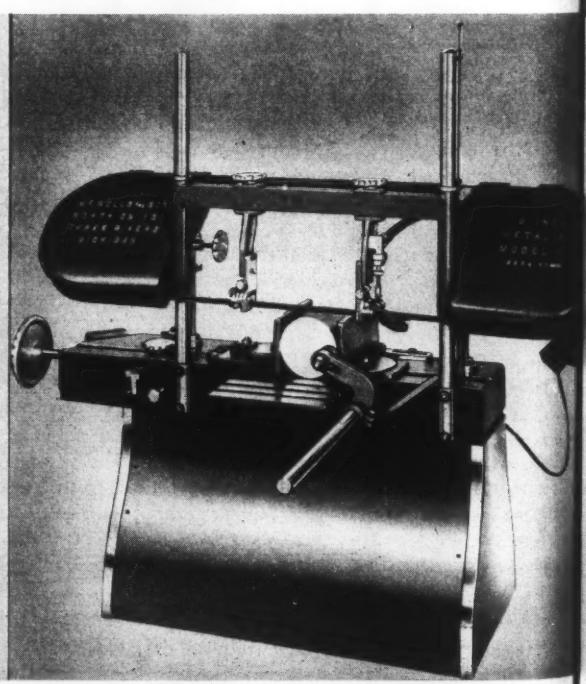
Metering Valve Controls Cutting Speed

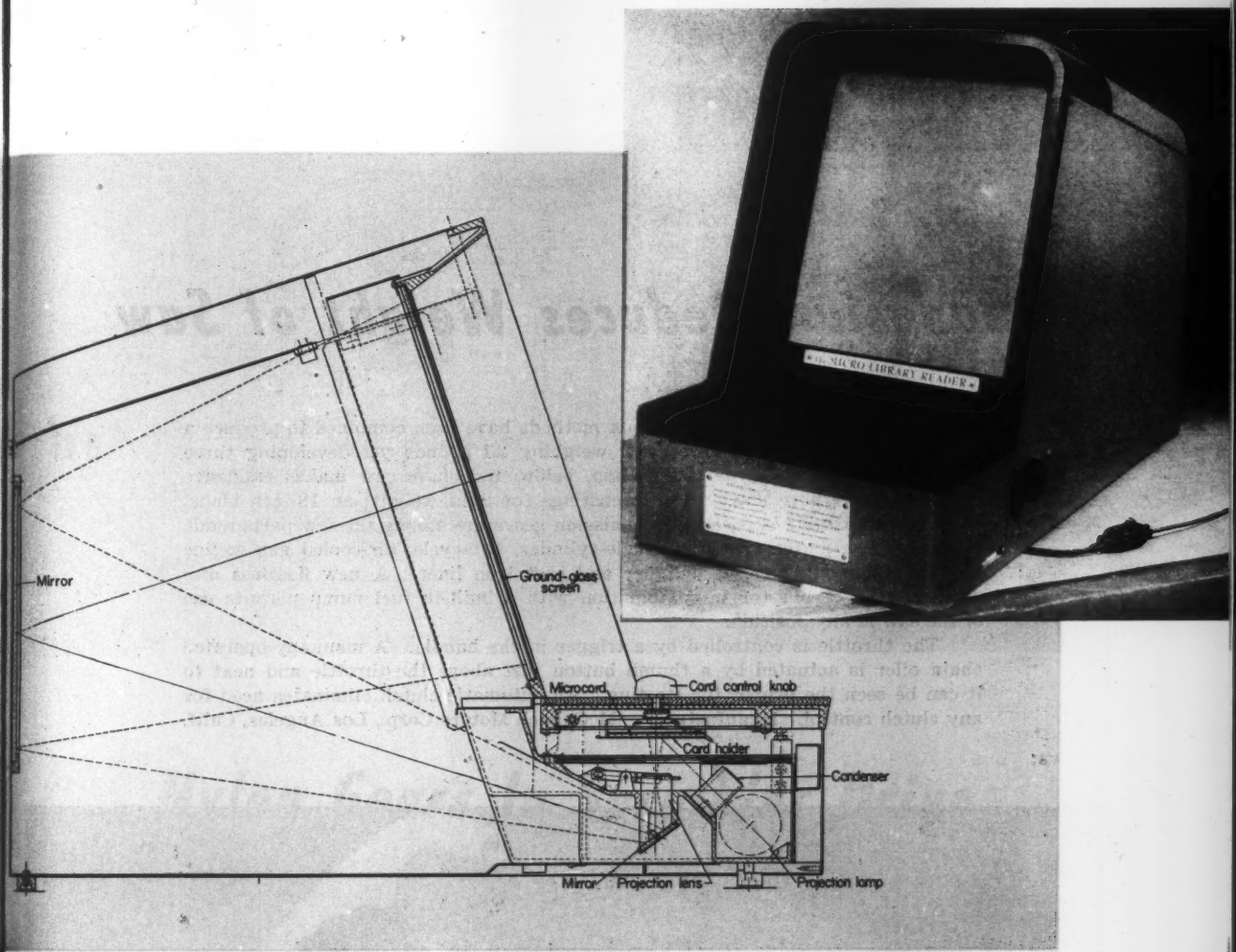
HYDRAULIC controls regulate the pressure being applied to the blade of the metal cutting saw, below, through the duration of the cut. Hydraulic cylinders exhausting through the metering valve control the rate of cutting. After a cut is completed, the cylinders raise the cutting head which is mounted on columns at each end of the machine.

The metering valve shown in the drawing operates as follows: A roller riding the back of the saw blade is linked to a needle valve through a double piston and diaphragm arrangement. A spring-loaded adjusting nut is set for the desired pressure of saw blade against the work. When the spring pressure is greater than blade pressure, the needle valve opens to permit flow of hydraulic fluid from the bottom of the cutting head cylinders, allowing the cutting head to descend. The needle valve thus regulates the descent rate to the speed at which the blade cuts.

At the completion of the cut, a limit switch starts the built-in hydraulic pump which feeds oil into the bottom of the cylinders, raising the cutting head to any desired height up to 20 inches. The saw has a maximum capacity of 9 by 18 inches. Manufacturer: W. F. Wells & Sons, Three Rivers, Mich.







Microcard Reader Requires Precision Optics

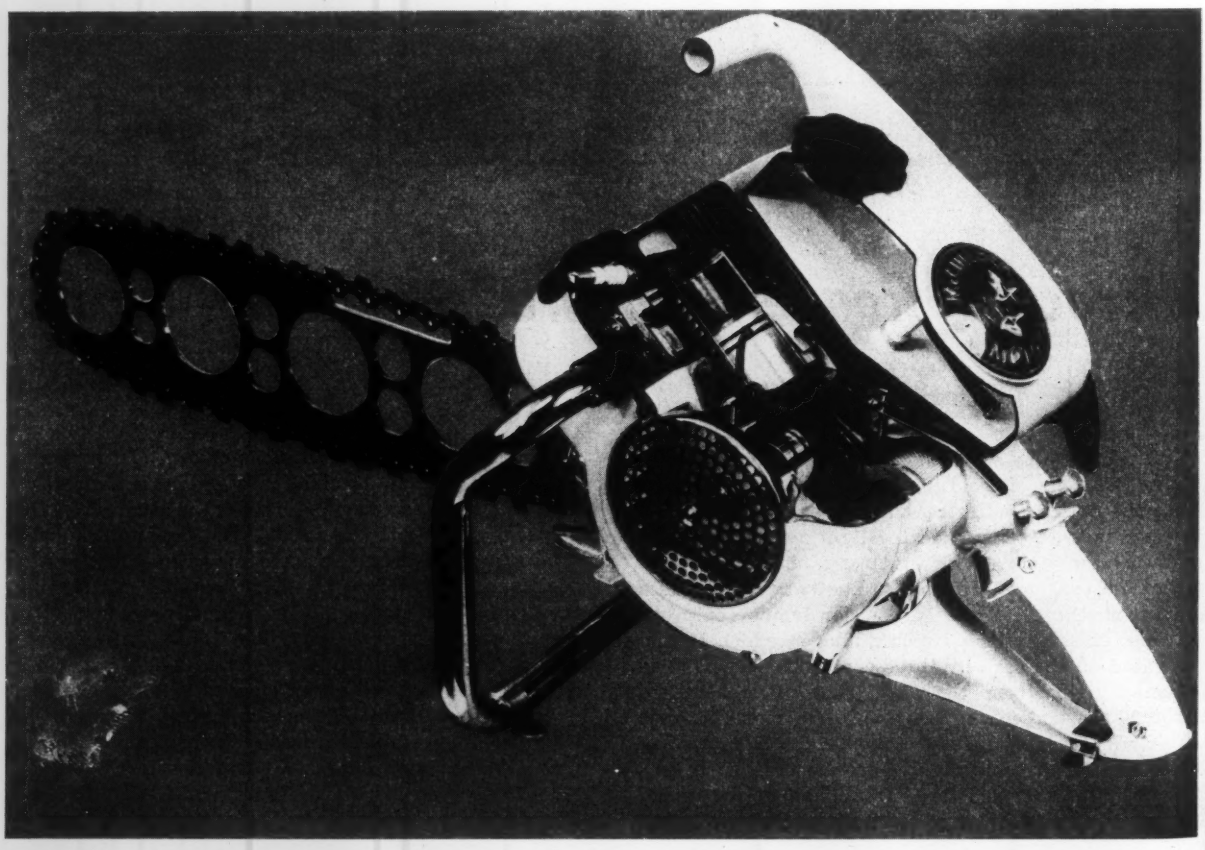
TEXT on five by seven-inch microcards is magnified 24 times in the Micro Library Reader shown above. Since the optics require reading of the microcards by reflected instead of transmitted light, an intense light source is necessary. This involves a severe heat concentration problem. The design finally developed uses light from three 100-watt projection lamps (only one of which is seen in the drawing above) which is concentrated on the card by three condenser lenses. The reflected light from the card is then transmitted through the projection lens, which is mounted with its axis in a vertical plane, and reflected from a small first-surface mirror located below the projection lens. The light then travels to the rear wall of the reader where it is again reflected from a larger first-surface mirror back to the ground glass screen. Heat is dissipated by a small automatically operated blower.

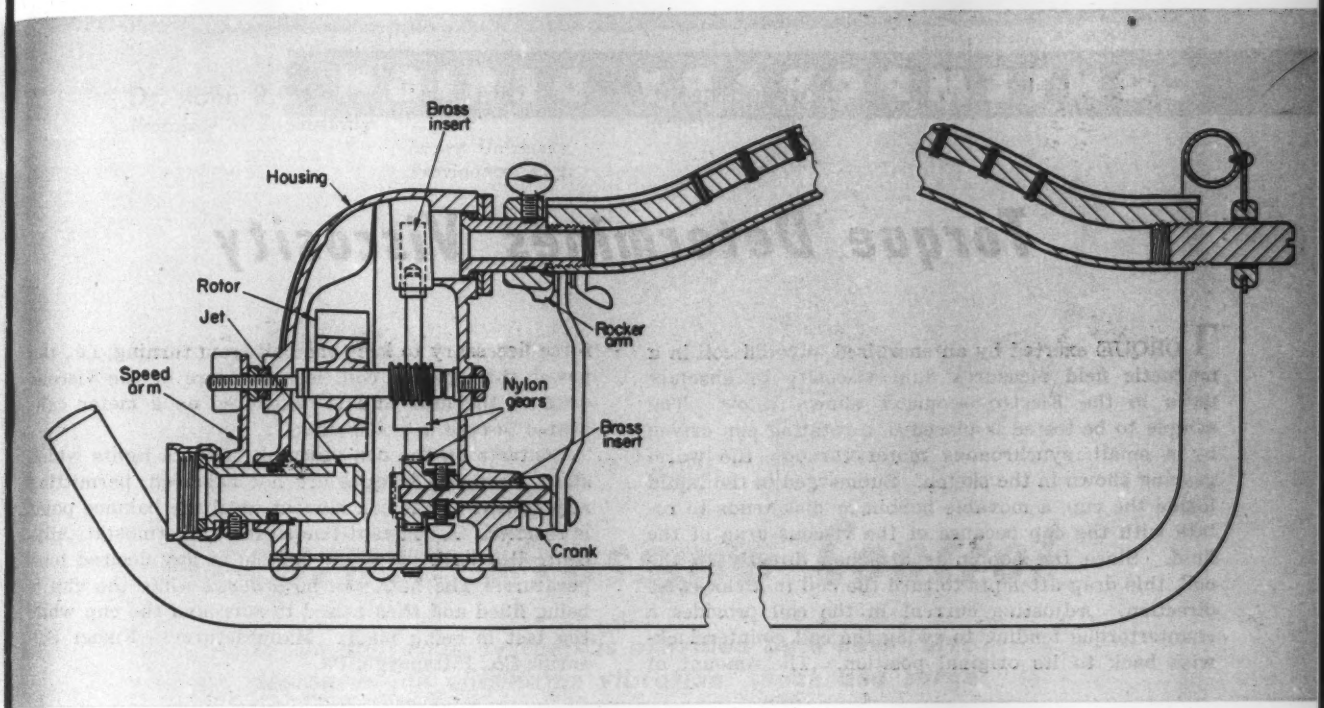
In order to read any page, a card is inserted in the holder by raising the deck lid. The card can be moved sideways by sliding the knob along the slot in the deck and is moved to the front or back by turning the same knob; horizontal or vertical movement thus results on the screen. Focusing the image is accomplished by turning the knob on the side of the unit which moves the projection lens up or down slightly. Special photographic equipment is used to reproduce up to 200 micro-text pages on each card. The machine was developed by Barnes & Reinecke Inc., Chicago. Manufacturer: Northern Engraving & Mfg. Co., La Crosse, Wis.

Magnesium Reduces Weight of Saw

MODERN materials and production methods have been combined to produce a well-engineered portable power saw weighing 25 pounds yet developing three horsepower. Shown in partial section, below, the chain saw makes extensive use of high-pressure magnesium diecastings for light weight; an 18-inch blade, cutter chain, handle bars, and transmission gears are among the few parts made of steel. The power unit is a single-cylinder, two-cycle, air-cooled gas engine with an aluminum diecast cylinder and cast iron liner. A new floatless diaphragm type carburetor in combination with a built-in fuel pump permits use of the saw in any position.

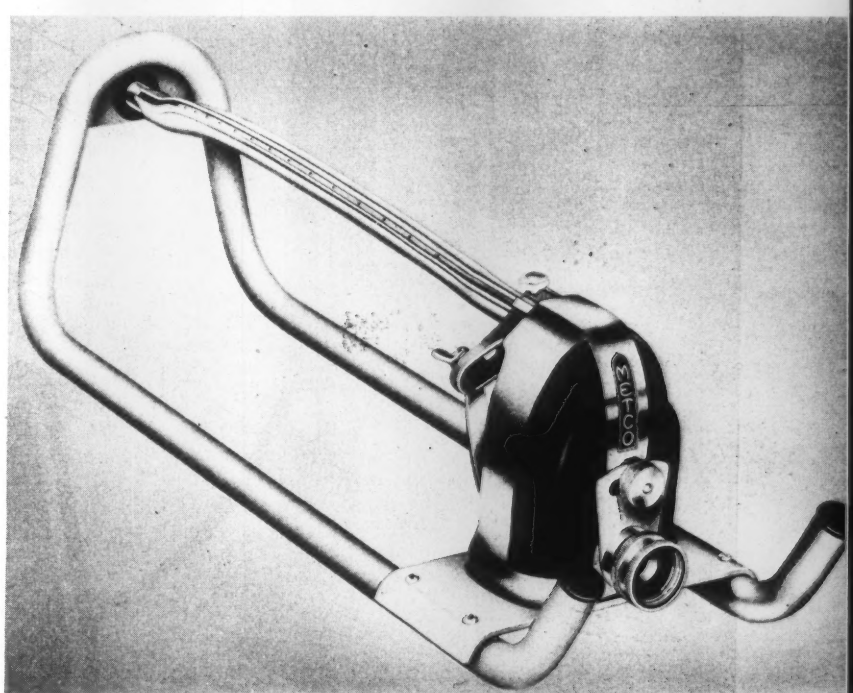
The throttle is controlled by a trigger in the handle. A manually-operated chain oiler is actuated by a thumb button just above the throttle and next to it can be seen the primer for starting. An automatic clutch eliminates need for any clutch control. Manufacturer: McCulloch Motors Corp., Los Angeles, Calif.





Nylon Gears In Sprinkler Drive

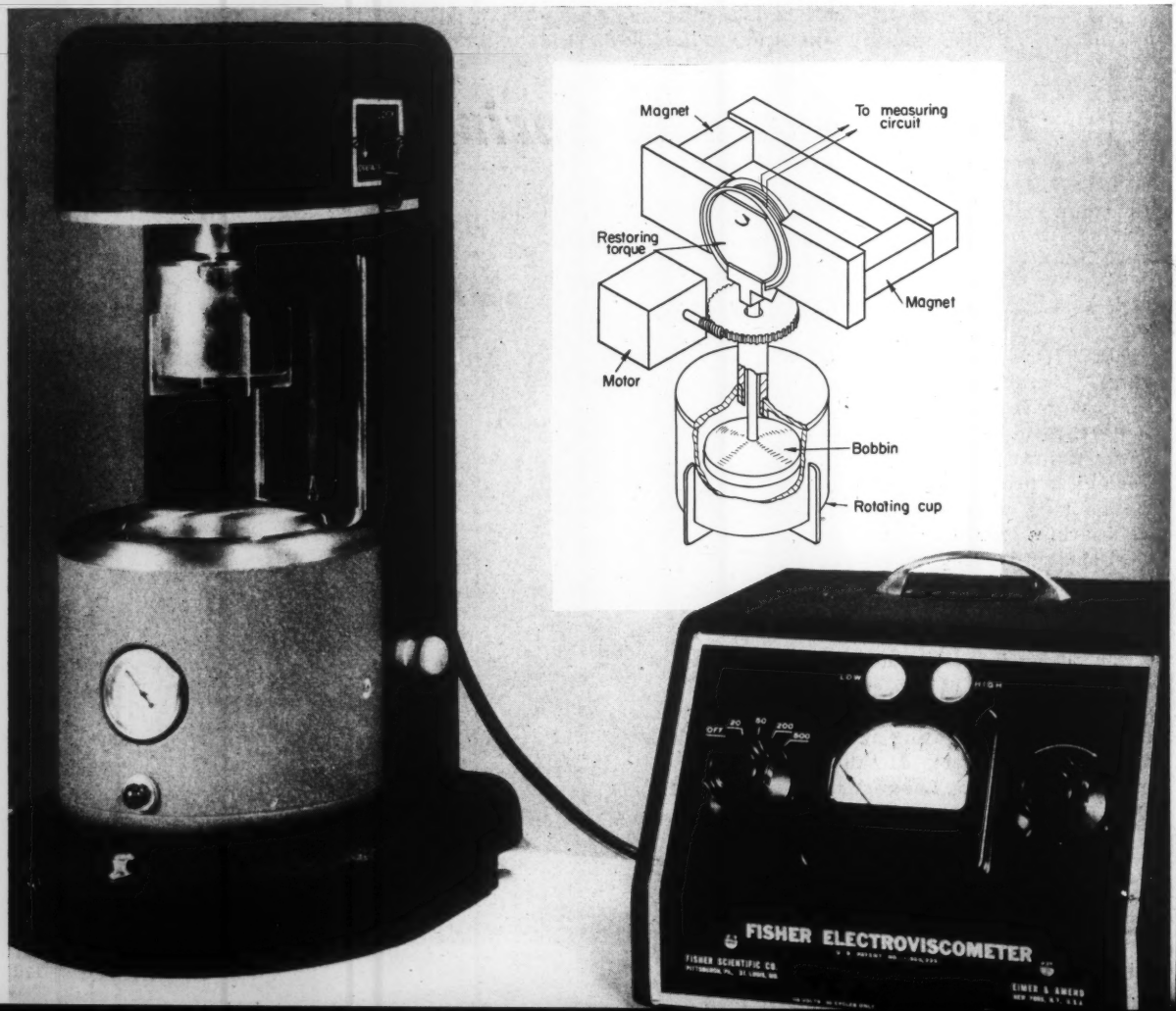
INJECTION molded nylon gears operating with brass worms drive the oscillating spray tube in the water-turbine powered lawn sprinkler, right. The unit is principally aluminum die castings, with brass inserts as bearings for the stainless steel shafts, drawing above. The rate at which the spray tube oscillates is controlled by adjusting the position at which the water jet strikes the turbine; directing this jet at the center of the turbine wheel stops the motor to permit watering at one spot. Manufacturer: Metallizing Engineering Co., Long Island City, N. Y.



Torque Determines Viscosity

TORQUE exerted by an energized, pivoted coil in a magnetic field measures fluid viscosity in absolute units in the Electroviscometer shown below. The sample to be tested is placed in a rotating cup driven by a small, synchronous motor through the worm gearing shown in the sketch. Submerged in the liquid inside the cup, a movable bobbin or disk tends to rotate with the cup because of the viscous drag of the fluid. Since the bobbin is attached directly to the coil, this drag attempts to turn the coil in a clockwise direction. Adjusting current in the coil provides a countertorque tending to swing the coil counterclockwise back to its original position. The amount of force necessary to keep the coil from turning, i.e., the power through the coil, is a measure of the viscous drag of the fluid and is registered on a meter calibrated to read in centipoises.

Contacts on the coil assembly actuate lights which show when the torques are not balanced, permitting adjustment of the coil current until the balance point is reached. A constant-temperature, thermostatically-controlled bath keeps the sample at any desired temperature. The bath can be lowered while the cup is being filled and then raised to surround the cup while the test is being made. Manufacturer: Fisher Scientific Co., Pittsburgh, Pa.



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and

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Accurate Pressure Control

. . . in hydraulic systems is provided by a new valve design which eliminates vibration, shock and surge

CONSTANTLY expanding application of automatic control with hydraulic circuits requires a high degree of reliability, precision and speed of operation. Paralleling modern trends of technical development towards greater precision, there has been a marked advance both in the theoretical analysis of the functioning and performance characteristics of hydraulic control systems. This advance, aided by ingenuity in design and high standards of quality in production of components, has led to a reduction of the complexity of such systems, increased their compactness and produced savings in weight and space requirements.

This development will be highlighted by the discussion of a significant element of hydraulic control, namely, the pressure relief control valve. The examples to be presented will point out the significance and scope of precision control and requirements in the various fields of application.

DEFINITION OF PRECISION CONTROL: As has been indicated, the meaning of precision control embraces not only precision of response of the hydraulic device to small changes of the controlling factor but also reliability of this response throughout a stated "life", so that constant and consistent repeat accuracy may be anticipated throughout the specified period of service. Precision also signifies speed of response, as is required, for example, in the case of cyclic operation at high frequencies to bring transient and nonsteady-state errors within admissible operating limits.

BASIC PRINCIPLES OF OPERATION: Hydraulic control devices may be divided into two groups, namely:

1. Automatic control devices responding to changes of some controlling quantity, such as pressure, within the system
2. Servo control devices responding to an externally applied mechanical force, which is small compared with the control action.

The present discussion will be confined to automatic control only.

Characteristics of operation of hydraulic control systems are fundamentally the same as those of regulating systems in general. Therefore, component performance analysis, as developed for regulating systems, forms the basis for the design of hydraulic devices.

COMPONENT PERFORMANCE ANALYSIS: Taking a pressure-control valve as an example, it is found that

variation or "error" of the primary quantity, namely the pressure, acting upon a "sensing" or "error measuring" member (which may be represented by a pilot valve loaded by a spring), will cause a controlled amount of energy available from the hydraulic fluid itself to be applied to and to actuate the "controller" (represented by the throttle or escape valve). This modulates the output (in the case in question; the quantity of flow) between given limits (say, from zero to maximum flow) as a function of the original error or variation of the primary quantity. Thus, as the throttle valve opens there may result a change in the pressure. In other words, the controller response may affect the primary factor. In that case a feedback may take place which, if utilized properly, may contribute to stable operation of the system.

An automatic pressure regulating valve, consequently, is a device combining a number of distinct yet closely integrated and compactly designed elements for the automatic control of the power of the working fluid. The various components and their interaction is shown diagrammatically in *Fig.* 1.

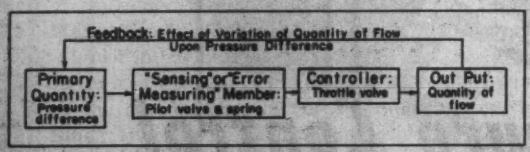

Feedback: Effect of Variation of Quantity of Flow Upon Pressure Difference
Primary Quantity: Pressure difference
"Sensing" or "Error Measuring" Member: Pilot valve & spring
Controller: Throttle valve
Out Put: Quantity of flow

Fig. 1—Diagrammatic representation of the components of an automatic pressure-control valve

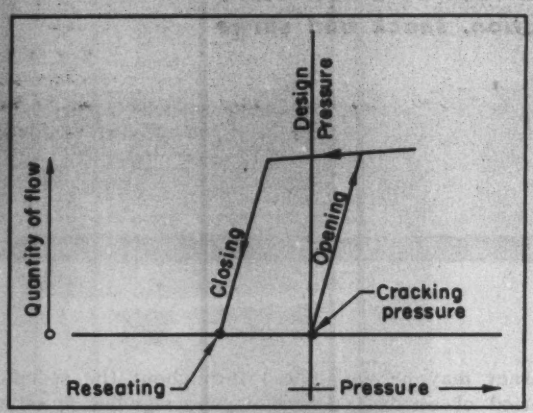
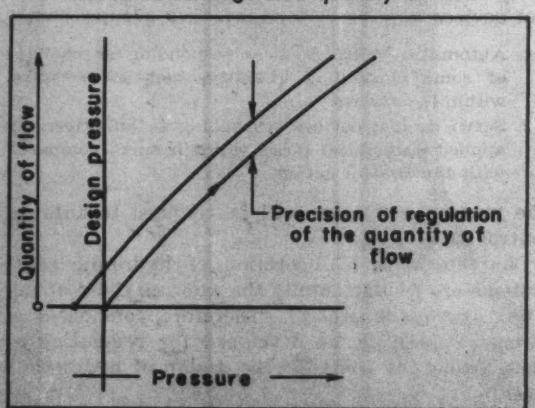


Fig. 2—Diagrammatic representation of "on-and-off" control valve action

Fig. 3—Below—Diagrammatic representation of control action for regulated quantity of flow



REGULATION: Several types of control may be achieved by proper choice of design constants. The type of control called for in certain services is "on-and-off" control, shown diagrammatically in *Fig.* 2. When a predetermined pressure, the cracking pressure, is exceeded, the valve is fully opened, establishing maximum flow. As the pressure drops, the valve closes at the reseating pressure and the rate of flow is zero. There is practically no control of quantity of flow between zero and maximum rate of flow.

Different characteristics of the design components of the control mechanism are called for if regulation of the output, i.e., controlled variation of the quantity of flow, is specified. In that case, shown diagrammatically in *Fig.* 3, the device must be error sensitive, i.e., the action of the controller upon the quantity of flow depends upon the difference of pressure and the quantity of flow becomes a function of that difference of pressure. In the case of nonsteady and transient operation, continuous change of the primary quantity is followed by a continuous change of the output, i.e., the rate of flow. The quality of regulation is the greater the more quickly and precisely the quantity of flow is established corresponding to a given value of the error.

Zero Velocity Desirable on Closing

DERIVATIVE CONTROL AND DEADBEAT OPERATION: A characteristic of great importance in hydraulic control devices, referred to as "derivative control," demands careful attention in design of components for minimum time lag of response. It is necessary that the motion of a valve, as it approaches the valve seat, be retarded as the distance between seat and valve is diminished so that the velocity is reduced to zero at the moment of closing. Thus overtravel and slamming or pounding with consequent damage to essential parts of the valve are avoided. Corresponding control of the velocity of valve motion may be used to control undesirable oscillations which, depending upon their frequency, produce whining at high frequency, howling at low frequency, and chatter with periodic slamming.

Effective derivative control, leading to absence of vibrations, establishes the desirable characteristic of "deadbeat" operation. Judicious application of solid friction between moving parts, of fluid friction, and of the dashpot principle are important means toward achieving deadbeat operation. Good design requires that damping action sufficient to eliminate oscillations, yet not so excessive as to render the response sluggish, shall be inherent in the design.

Experience has shown, however, that it is not suf-

ficient to consider the dynamic vibrational characteristics of a hydraulic device, such as a pressure-regulator valve, by itself. It is necessary to consider the entire hydraulic system—particularly in high pressure systems where large amounts of energy are available for sustaining oscillations. Assurance of satisfactory dynamic characteristics under all possible installation conditions often calls for the incorporation of effective dashpot action in the valve design.

ELEMENTS OF DESIGN OF PRESSURE-CONTROL VALVES: Design principles of modern hydraulic control devices will be illustrated further by a brief discussion of basic elements and alternative design solutions for pressure control valves. The simplest type of pressure-control valve undoubtedly is the ball and spring type, *Fig.* 4. It is found satisfactory under certain conditions for "on-and-off" control. A cone type valve, *Fig.* 5, with the valve centered with respect to the seat, permits certain refinements in the variation of quantity of flow with pressure. Because of the forces involved, sensitivity to pressure changes will be low for springs of limited dimensions. Damping of vibrations is low unless dashpot action is provided. The "pop" safety valve, *Fig.* 6, effectively eliminates both slamming and vibrations because of the collar around the valve seat and the dashpot above the valve guide. The partly balanced valve, *Fig.* 7*a*, permits the use of a weaker and softer spring for a given operating pressure range and size of valve and, therefore, favors the attainment of greater sensitivity. Variation of the size of the central bore will produce a change in the dashpot action of the space above the valve body. The rubber O-ring serves two purposes, namely it stops leakage across the valve in valve-closed position and, by its friction and in combination with the dashpot, eliminates vibrations of the valve body.

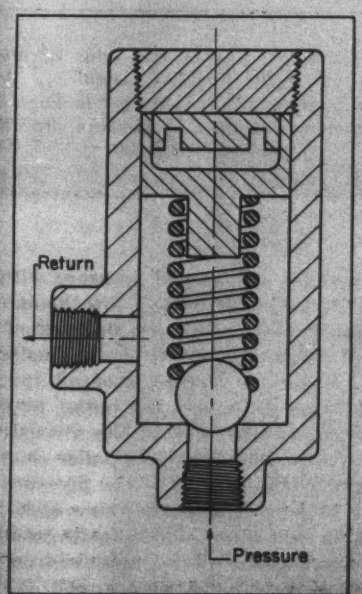
At very high pressures, across the valve, the O-ring friction was found to decrease the sensitivity of the valve action to pressure changes. The corresponding design for maximum sensitivity, yet having a certain amount of continuous leakage because of the absence of the O-ring, is indicated at *b* in *Fig.* 7.

Compact Valve Evolved

PANTEX PRESSURE-RELIEF VALVE: A new pressure-relief valve developed in strict adherence to the foregoing principles of modern precision control is shown in *Fig.* 8. Its performance meets or exceeds government specifications and the most rigorous industrial requirements. An outstanding feature achieved by the slow process of design evolution is compactness, even for highest pressures. Compactness, as well as the particular requirements of precision control of reliability over a long period of service, have been obtained by high standards of production and the application of the principles of quality control.

In order to enhance the inherent advantages of hydraulic control, a cartridge design has been adopted to permit ease of servicing without highly specialized skill. Vital parts of the valve can be removed, with-

Fig. 4—Simplest type of pressure-control valve design with ball and spring. Ball must be accurate



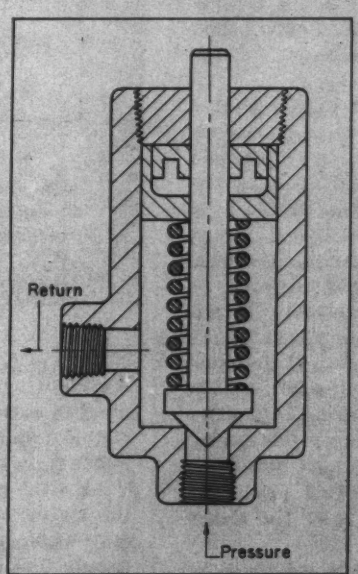
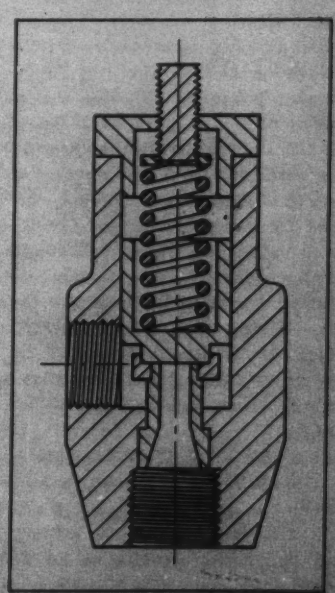


Fig. 5—Cone type pressure-control valve is a refinement over ball type but sensitivity may be low

Fig. 6—Dashpot action of "pop" type valve eliminates vibration and slamming



out breaking the lines, and replaced by another identical unit or, because of interchangeability of parts, by a unit designed for a different pressure.

The essential parts of this valve are: (1) A pilot valve of a small size loaded by a spring of small coil diameter capable of producing a force sufficient to keep this valve closed against design pressure, and (2) the master valve, which is of the sleeve type, held on its beveled seat by a spring of larger diameter. The upper part of the master valve forms an annular piston and a dashpot.

The master valve is guided on its internal cylindrical surface by the valve guide and the external surface of the poppet housing. An O-ring provides an effective seal against leakage from the high-pressure inlet ports to the outlet ports of the valve. On its outside surfaces, the master valve fits with relatively greater clearance into the valve housing, the lower portion at a smaller diameter than the upper, so as to produce the annular piston referred to in the foregoing.

All parts of this valve are assembled in units, the principal parts forming a cartridge for quick and simple replacement. The spring tension of the pilot valve may be adjusted for desired operation without disassembly of the valve, whereas the master valve spring tension is fixed by the design at a predetermined value.

Pressures to 10,000 psi Possible

The pilot valve is held on its seat by spring force operating against the force created by the pressure differential across the valve. The range of design pressures is from 100 to 5000 psi for standard valves, although during burst tests conducted in the laboratory of the Pantex Mfg. Corp. it has been established that valves will withstand 10,000 psi without leakage toward the outside.

Valve Operation: The pressure relief valve operates in the following manner. The pilot valve, representing the sensing element, responding to the upstream pressure as the controlling factor, will open as the upstream pressure exceeds the value determined by adjustment of the pilot valve spring, within the range from 100 to 5000 psi for the standard design. Response takes place within 7 per cent of selected pressure.

As the pilot valve opens, inlet pressure is admitted to the space below the annular piston of the master valve and likewise through a port in the master valve sleeve, to the O-ring, sealing the latter. This operation tends to balance the pressure on both sides of the O-ring and, consequently, reduces the O-ring friction to an inconsequential factor. At the same time, upstream pressure is also admitted below the annular piston forming the upper part of the sleeve valve.

Since the area of the sleeve valve acted upon by the upstream oil pressure, namely, the annular area between the outer and inner diameter of the sleeve, is small, the pressure force acting upon this valve is small and, consequently, a relatively weak spring is adequate to keep the sleeve valve closed. By contrast, however, the effective area of the annular piston forming the upper part of the sleeve is large and, therefore, only a slight increase of pressure with respect to outlet pressure in the space below the annular piston (which takes place upon the opening of the pilot valve) will open the sleeve valve instantly.

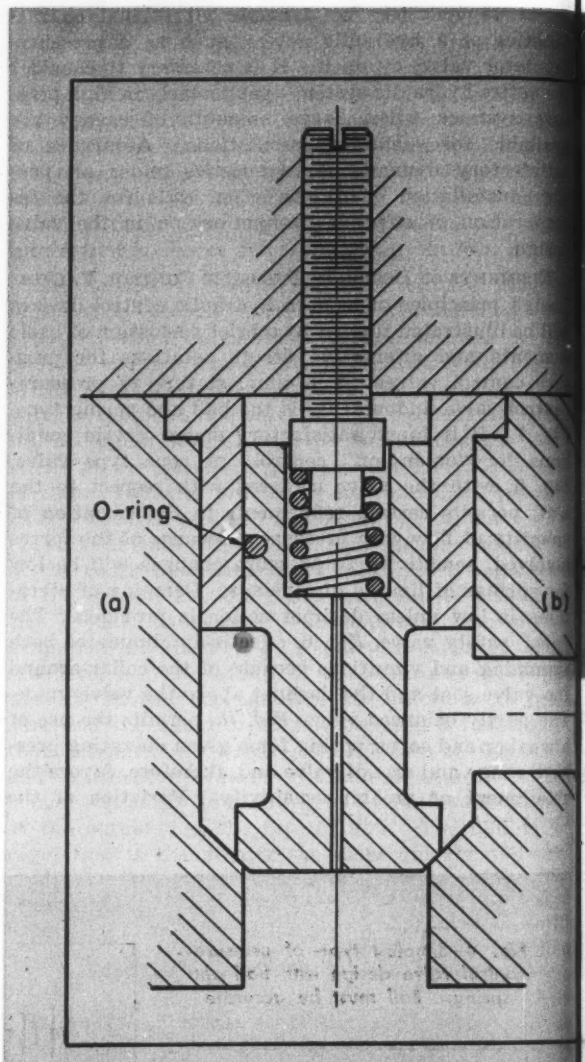


Fig. 7—Partly balanced valve eliminates vibration with O-ring as at (a) has low sensitivity. With O-ring as at (b) sensitivity is better but leakage is high. Premature opening is caused by pressure drop through small drilled hole

As soon as this occurs, discharge of oil through the sleeve valve takes place and the outlet pressure may assume any value desirable in the downstream supply line up to a maximum value smaller than the upstream pressure by the amount of the pressure difference required to keep the sleeve valve open. As has been stated, this pressure difference is small. It is of the same magnitude as the pressure drop produced by flow losses through the valve.

Tests have indicated that, at quantities of discharge greatly in excess of the rated quantity, the pressure

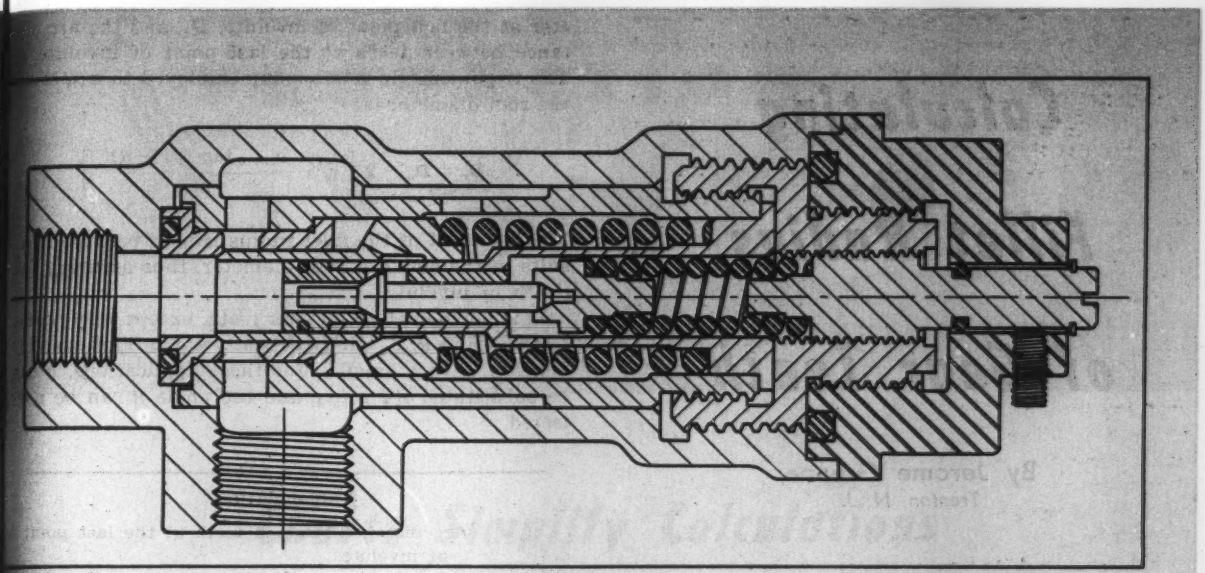


Fig. 8—Cross section through new Pantex high precision cartridge design pressure-control valve

drop through the valve exceeds the pressure difference necessary to keep the valve open. Nevertheless, the design insures that the pressure forces acting on the sleeve valve body will never exceed safe values. The flow losses in the valve are kept down to such a value that they represent no problem. At very small quantities of flow and in case the back pressure is at a minimum, the sleeve valve is expected to be partially open. Wiredrawing and its consequent harmful effects, such as whining and erosion of valve and seat, inherently cannot occur because the design permits only a low and definitely limited pressure drop to occur across the sleeve valve. Maintenance and servicing are simplified because of the fact that the sleeve valve spring requires no adjustment whatever, nor is the magnitude of its spring force critical for the operation of the valve, all the adjustment being accomplished by the setting of the pilot valve spring.

In closing, the valve operates in the following manner. As the upstream pressure drops below the value fixed by the setting of the pilot valve spring, the pilot valve closes. As this occurs, the sleeve valve being open, the oil filling the space under the annular piston is enclosed in a closed chamber except for the leakage which can occur through the clearance between the outer surface of the sleeve valve and its upper bushing on one hand, and the clearance around the outer perimeter of the annular piston and the cartridge case on the other hand. Both clearances are generous as the fit is loose. Their values are chosen judiciously with careful regard to the properties of the oil, such as operating temperatures and viscosity, as well as to the characteristics required of the valve. Design instructions regarding these clearances are checked by calibration tests for each application.

The combination of the oil space under the annular piston and of the clearance passages constitutes a dashpot which has the operating properties required to produce the desired amount of damping. It is significant that the sleeve valve and spring action, subject to the control of the dashpot, will return gradually to its seat, avoiding slamming or violent impingement between valve and seat. The time required for closing the sleeve valve from the moment the upstream pressure has dropped below the selected value is only a small fraction of the time allowed in performance specifications. Dependable precision operation has been obtained with the valve while opening and closing the downstream oil line in a two-second cycle. In addition to establishing favorable characteristics in closing the sleeve valve, dashpot action, in conjunction with the slight amount of friction produced by the O-ring, also eliminates vibrations or chatter.

LOW-TEMPERATURE refrigeration is being used by an English manufacturing plant in airplane propeller processing operations. The Air Screw Co. of Weybridge had occasion to remove laminated wood propellers from the steel ferrule by which they are fastened to the propeller boss in the engine shaft. The blade is screwed into the ferrule and a special cement used to insure a tight bond. The force required to break away the cement when unscrewing prevented ordinary methods of removal.

Since wood contracts about three times as much as steel when temperatures are reduced, a low-temperature cabinet was constructed to chill the entire hub assembly, eight blades at a time. Between six and eight hours are required for the majority of blades to shrink sufficiently to allow them to be easily removed from the hub.

Calculating Fillet Radius of Gear Teeth

By Jerome Greene
Trenton, N. J.

DETERMINING by layout the fillet radius for full-fillet type gear teeth requires very accurate large-scale layouts, sixty times full size being necessary occasionally. This article describes a quick, accurate method for calculating the fillet radius.

The construction method for full-fillet gear teeth is shown in *Fig.* 1. With the aid of this drawing, trigonometric relations of the data listed in the accompanying Nomenclature can be derived. These relations, used to determine the fillet radius of full-fillet gear teeth, are:

$$\cos \phi_a = \frac{D}{D_a} \cos \phi$$

$$t_a = D_a \left[\frac{t}{D} + \text{inv } \phi - \text{inv } \phi_a \right]$$

$$p_a = p \left(\frac{D_a}{D} \right)$$

$$a = p_a - t_a$$

$$\text{arc } \beta = \frac{a}{D_a}$$

$$a_{chord} = D_a \sin \beta$$

$$r_f = \frac{a_{chord}}{2 \cos (\phi_a + \beta)}$$

Tooth thickness is a toleranced dimension resulting in two answers for the fillet radius, corresponding to the high and low limits. Specifying the fillet radius as a toleranced dimension will not permit a smooth transformation where the involute joins the fillet. Smooth transformation is obtained by specifying the root diameter, D_r, as a toleranced dimension and the fillet radius as an approximate dimension. The root diameter is a function of the root radius, r_f, the pressure angle at the last point of involute, ϕ_a, the diameter at the last point of involute, D_a, and the arc distance between teeth at the last point of involute, a. The trigonometric relationship employed to determine the root diameter is:

$$D_r = D_a - 2 \left[r_f - \frac{a_{chord} \tan (\phi_a + \beta)}{2} \right]$$

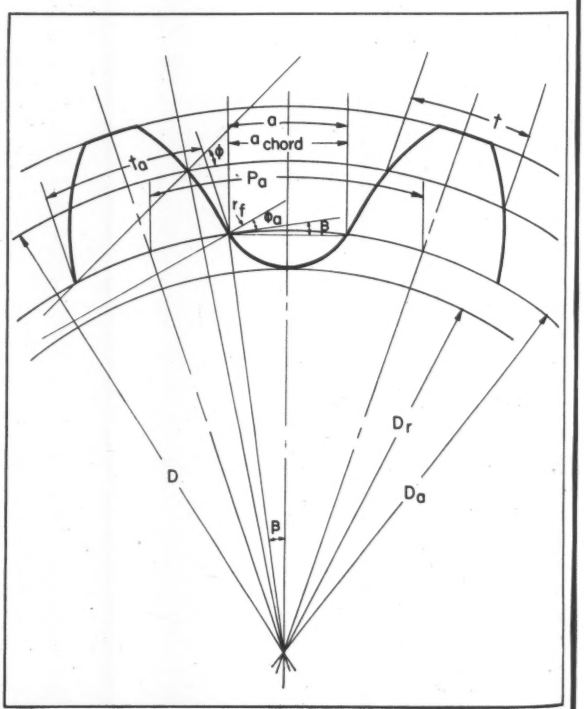
The low limit of the fillet radius is used because it results in the smallest root diameter, thus assuring full depth of involute.

It is noted that on all gear teeth, except very coarse teeth, a and a_{chord} are practically equal, and that the angle β is very small. For these applications, a can be substituted for a_{chord}, and the angle β can be neglected.

Nomenclature

a = Arc distance between teeth at the last point of involute
a_{chord} = Chordal distance between teeth at the last point of involute
D = Pitch diameter
D_a = Diameter at the last point of involute (determined by the desired contact ratio)
D_r = Diameter of root circle
P = Diametral pitch
p = Circular pitch
p_a = Circular pitch on circle D_a
t = Circular thickness of tooth on pitch circle
t_a = Circular thickness of tooth on circle D_a
ϕ = Pressure angle on pitch circle
ϕ_a = Pressure angle on circle D_a

Fig. 1—Construction of full-fillet type gear teeth



Charts Simplify Calculations

By Tyler G. Hicks
Mechanical Engineer
Summit, N. Y.

Part 1–Bending Forces

A CONSIDERABLE portion of design time for a given machine is spent determining the best production procedure for each member of the machine. The time devoted to this study may be costly, especially when the design is different from others recently produced by the firm. In such cases there is often a certain amount of lost motion resulting from incomplete manufacturing specifications. Lack of completeness in specifications has been traced to insufficient design room data on shop equipment performance, capacities, and limitations. To facilitate correlation of desired design characteristics and manufacturing procedures, a series of charts for major production operations has been developed. Six of these charts will be presented successively beginning with this issue, together with examples of their use in typical machine design problems.

DESIGN CHARTS: Extensive design experience has shown that some of the most frequently recurring planning calculations involve time, force, power, and allowable feeds for various machines. The charts to be presented in this series permit direct graphical determination of the following: (1) Bending force necessary for a machine member when the dimensions, type of die, and material properties are known, (2) power required for punching holes of known size in plates of given material, (3) drawing force for a machine member when the factors listed in (1) are known, (4) cutting time for machine members whose size is known, (5) allowable feeds for milling machines of given horsepower when working on specific parts whose design features are known, and (6) milling time for members of given dimensions.

"Indirect" solutions, i.e., those obtained by reversing the solution path or starting from within the charts and working out, will yield up to thirty-three factors encountered in various phases of the design of a machine. Thus, a total of thirty-nine variables can be evaluated. Data needed for these solutions are those which normally must be considered during good design of all machine members, mechanisms, and application of materials.

Results given by the charts are sufficiently accurate for every class of work encountered in the usual design office. In cases where mathematical solutions are required as a matter of policy, the charts are handy for checking purposes and will generally aid in spotting errors. Application of these charts has shown that the ranges and forms of presentation chosen are satisfactory from the standpoint of time, effort, and accuracy. In most cases, problems can be roughly solved with one hand by drawing a free-hand path of the solution. Such a procedure will indicate, for instance, whether a value is nearer 100 or 600. Exact solution, using a triangle and straightedge, would show that the actual value is 155 or 585, according to conditions.

BENDING FORCES: The first chart on the following

page permits quick estimates of the bending force required for all metals when the length of member, its thickness, width of die, and ultimate tensile strength of the material are known.

Example: A 27-inch long, 3/16-inch thick bar is to be bent in a V-shape die which is ¼-inch wide. What bending force is necessary if steel with an ultimate tensile strength of 120,000 psi is used for the bar?

Enter the chart at a length of 27 inches and project horizontally to the 3/16-inch thickness curve. From here project vertically to the 120,000 psi ultimate tensile strength curve and then across to the ¼-inch die width curve. At the bottom read the bending force as 228 tons.

This result is valid for V-shape dies only. For channel forming and U-shape work, use the lower scale in the chart. Thus, in the above case, if the bar were being bent into a channel shape, bending force required equals 456 tons, say 460. In channel forming, when channel bottom must be exactly flat, a blank holder is necessary. To obtain the total bending force for this condition, multiply blank holder area in square inches by 0.15 and add to the bending force obtained from the chart.

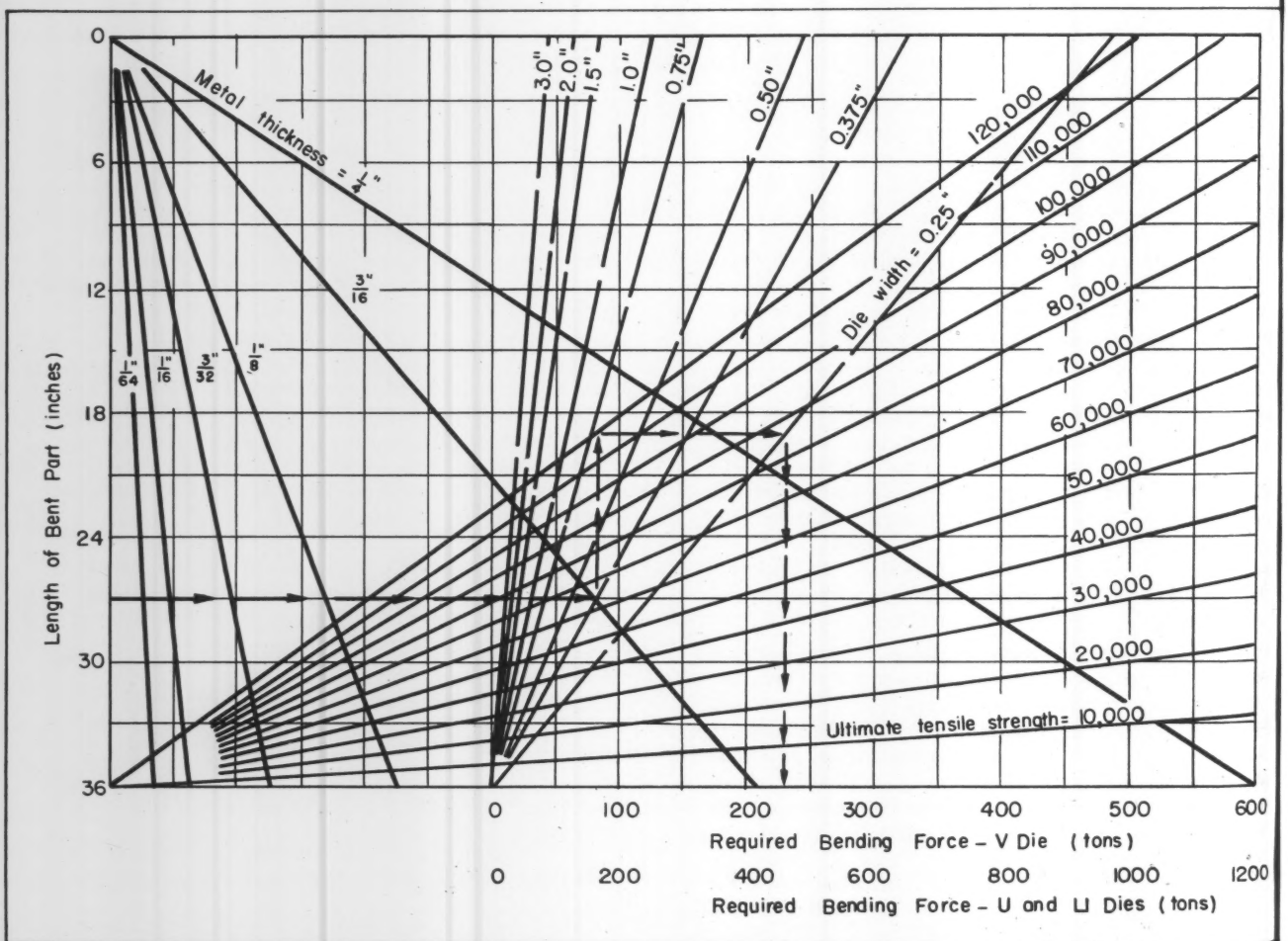
Sizes Beyond Chart Practical

This chart is suitable for any shape, provided that the proper length is used when entering. If any value, such as bend length, die width, or ultimate strength is beyond the limits of the chart, divide all values except metal thickness by a suitable number and solve as above. Multiply the result by this number to obtain the bending force. The chart is based on the following formula

$$F_b = (Lt^2/w)S$$

where

F_b = Required bending force, tons
L = Length of bent part, inches
t = Metal thickness, inches
w = Width of the V, channel, or U lower die, inches
S = Ultimate tensile strength of material, tons per sq. in.



Springs

Determining maximum energy in a minimum length for a given coil diameter

By Norman W. Carey
Stress Analyst
Bartelt Engineering Co.
Rockford, Ill.

Fig. 1—Springs designed for limited space on the drive of an electric locomotive

MORE and more in these days of advancement in engineering, the problem of designing a spring to meet a specific energy requirement over a given travel is being met. Many times the space requirement, insofar as length and diameter are concerned, is a minimum such as in *Fig.* 1. The problem then is, can a spring be designed to meet these conditions? There are three factors determining the length of a spring; namely, travel or working distance, total clearance between coils at minimum working height, and the solid height of the spring. The first is dictated from the requirements of the job to be done; the second is largely governed by recommended engineering practice. This leaves only the third with which to work.

For efficient use of metal, the spring should be designed with the minimum solid height. Since the solid height is directly proportional to the number of coils, it is desirable to have a minimum number of coils for any given wire diameter. Since there is also the limitation of the outside diameter of the spring, the minimum number of coils must be found for the specified outside diameter for any value of wire diameter.

* Mr. Carey is now development engineer at Bauer & Black, Chicago 16, Ill.

The following four formulas are generally accepted and their validity will not be questioned:

$$F_e = \frac{\pi S d^3}{16rK} \quad \ldots\ldots (1)$$

$$o = \frac{64F_e r^3 N}{Gd^4} \quad \ldots\ldots (2)$$

$$k = \frac{Gd^4}{64r^3N} \quad \ldots\ldots (3)$$

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C} \quad \ldots\ldots (4)$$

From *Fig.* 2 the energy is obviously equal to

$$U = \frac{\delta(F_0 + F_1)}{2} \quad \ldots\ldots (5)$$

Also, the load F_o at minimum operating height and the preload or load F_1 at assembled height are

$$F_0 = F_e - bk \quad \ldots\ldots (6)$$

$$F_1 = Fe - (b + \delta)k \quad \ldots\ldots (7)$$

Substituting Equations 6 and 7 in Equation 5 yields

$$U = \tfrac{1}{2}\,\delta(2F_e - 2bk - \delta k) \quad \ldots\ldots (8)$$

Making use of Equations 1 and 3 in Equation 7, and solving for N gives

$$N = \frac{Ad^4}{(Bd^3 - r)r^2} \quad \ldots\ldots (9)$$

where the constants A and B have been substituted for the following:

$$A = \frac{\delta(2b + \delta)G}{128U} \quad \ldots\ldots (10)$$

$$B = \frac{\pi S\delta}{16KU} \quad \ldots\ldots (11)$$

Differentiating Equation 9 with respect to r gives

$$\frac{dN}{dr} = \frac{-Ad^4(2Bd^3r - 3r^2)}{(Bd^3r^2 - r^3)^2} \quad \ldots\ldots (12)$$

Equating this to zero yields for any given d a value for r for which N will be a minimum. That is,

$$r = 2\,\frac{B}{3}\,d^3 \quad \ldots\ldots (13)$$

Making use of this relation in Equation 9,

$$N = \frac{27}{4}\left(\frac{A}{B^3}\right)\frac{1}{d^5} \quad \ldots\ldots (14)$$

In evaluating A and B, Equations 10 and 11, it is necessary to establish values for the stress S and the Wahl factor K, in choosing a value for the stress, it is well to keep in mind the life expectancy as well as the type of operation of the spring. An estimate for K can be made and, after finding r from Equation 13, it is possible to evalute the spring index $C = 2r/d$. Using this in Equation 4, the true value of K may be found. If this is higher than the estimate, the percentage increase is multiplied by the chosen value for the stress and the result will be the actual stress. If the true value for K is smaller than the estimate, the actual stress is less by the percentage decrease from the estimated K.

Correction For Actual Stress

If a long-life spring is being designed, the chosen value for the stress is usually well below the yield point of the material. Hence K can be assumed equal to unity and, when the true value of K is found, it may be multiplied by the chosen value for the stress to find the actual stress.

For any given wire diameter, Equation 13 yields the correct value for r such that, using the same value for d in Equation 14 N will be a minimum. Solving Equation 13 for d gives

$$d = \sqrt[3]{\frac{3r}{2B}} \quad \ldots\ldots (15)$$

Since the outside diameter D is known and $r = \tfrac{1}{2}(D - d)$, allowing an amount ϵ that looks reasonable for the manufacturing tolerance and the growth involved in compressing to solid height, Equation 15 becomes

$$d^3 = \frac{3}{2B}\left(\frac{D}{2} - \frac{d}{2} - \epsilon\right) \quad \ldots\ldots (16)$$

Solving this for d will produce the exact value, but since it is possible and even probable that this will not produce a size that is readily available in the commercial field, a quicker method is to substitute $D/2$ for r in Equation 15 and evaluate d

From a commercial stock list of available wire sizes, the next smaller size should be chosen. Substituting this value in Equation 13 for d will usually yield an r that will fulfill the requirements. If the resulting r is still slightly high, or low, it may be changed numerically to the desired value. As long as these changes are small their effects will usually be less than those resulting from the manufacturing tolerance. The solid height of the spring is then:

$$H_s = (N + 2)d \quad \ldots\ldots (17)$$

The value of the constant, may be 2, as in Equation 17, or somewhat less depending on the type of spring end required. Commercial spring manuals give values for various spring-end conditions. To further aid the designer, substituting Equations 10, 11, 13, and 14 in Equations 1, 2, and 3 yields

$$F_e = \frac{3U}{2\delta} \quad \ldots\ldots (18)$$

$$\rho = \frac{3}{2}(2b + \delta) \quad \ldots\ldots (19)$$

$$k = \frac{U}{\delta(2b + \delta)} \quad \ldots\ldots (20)$$

It is evident from these latter three equations that it is not even necessary to compute d, r, or N to obtain the maximum load, maximum deflection, and rate of the spring. Using these in Equations 6 and 7

Nomenclature

- A = Defined constant, introduced for convenience
- B = Defined constant different from A, also introduced for convenience
- b = Total clearance between coils at minimum working height, in.
- C = Spring index, $2r/d$
- D = Diameter in which spring must operate, in.
- d = Wire diameter, in.
- F_e = Load at maximum deflection, lb
- F_0 = Load at minimum operating height, lb
- F_1 = Load at assembled height, usually referred to as preload, lb
- G = Torsional modulus of rigidity, psi
- H_a = Assembled height, in.
- H_s = Solid height, in.
- K = Wahl correction factor
- k = Spring rate, lb/in.
- N = Number of active coils
- r = Mean radius of coils defined with spring under zero load, in.
- S = Stress at load F_e, psi
- U = Energy required from spring, in-lb
- δ = Travel over which the energy U must accumulate, in.
- ρ = Deflection producing or produced by load F_e, in.

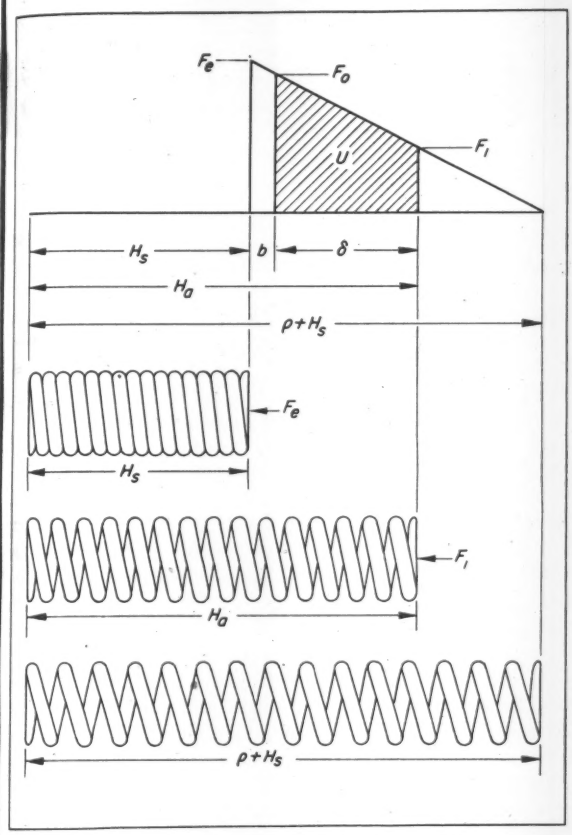


Fig. 2—Load deflection diagram for a compression spring showing stored energy in compression from preload to minimum operating height

$$F_0 = \frac{U}{\delta}\left(\frac{2b + 1.5\delta}{2b + \delta}\right) \quad \ldots\ldots (21)$$

$$F_1 = \frac{E}{\delta}\left(\frac{2b + .5\delta}{2b + \delta}\right) \quad \ldots\ldots (22)$$

For determining the ratio between the preload and the load at minimum operating height Equation 22 is divided by 21 yielding

$$\frac{F_1}{F_0} = \frac{2b + 0.5\delta}{2b + 1.5\delta} \quad \ldots\ldots (23)$$

It is readily seen that if b were made zero this ratio would equal one third and if δ were made zero it would be one. Since both of these cases are impracticable and the latter meaningless the following holds:

$$\frac{1}{3} < \frac{F_1}{F_0} < 1$$

The ratio depends solely upon b and δ, but since δ was given it will depend only on the choice for b. This choice must be made at the start of the solution.

EXAMPLE: Design a spring that will produce 300 in-lb of energy over a travel of 2.00 in. This spring must operate in a 1.500-in. diameter hole with the minimum spring length. Given: $U = 300$ in-lb, and $\delta = 2.00$ in.

Assume, when the spring has compressed to its full operating length of 2.00 inches, that there is still a total clearance, b, between coils of 0.25 in. From Equations 18, 19, 20, 21, and 22,

$$F_e = \frac{3}{2}\left(\frac{300}{2.00}\right) = 225 \text{ lb}$$

$$\rho = \frac{3}{2}[2(0.25) + 2.00] = 3.75 \text{ in.}$$

$$k = \frac{300}{2.00(2.50)} = 60 \text{ lb/in.}$$

$$F_0 = \frac{300}{2.00}\left(\frac{0.5 + 3.00}{0.5 + 2.00}\right) = 210 \text{ lb}$$

$$F_1 = \frac{300}{2.00}\left(\frac{0.5 + 1.00}{0.5 + 2.00}\right) = 90 \text{ lb}$$

Evaluate A and B from Equations 10 and 11. Since steel wire will be used, $G = 11.5(10)^6$. Assume $S = 125{,}000$ psi and $K = 1.15$. Then

$$A = \frac{2.00(2.5)(11.5)(10)^6}{128(300)} = 1497.40$$

$$B = \frac{\pi(125000)(2.00)}{16(1.15)(300)} = 142.282$$

Using A and B in Equation 13,

$$r = \frac{2}{3}(142.282)d^3 = 94.8547d^3$$

Substituting $0.5D = 0.75$ for r and solving for d,

$$d = \sqrt[3]{\frac{0.75}{94.8547}} = \sqrt[3]{.007907} = 0.1992 \text{ in.}$$

Commercial Wire Size Is Chosen

The next smaller commercial wire size is $d = 0.192$-in. Using this, $r = 0.67137$ but the OD is too large. Trying $d = 0.1875$, then $r = 0.6253$ in., which is satisfactory. Therefore, OD $= 2r + d = 1.4381$ in.

Using Equation 14 to determine the number of active coils,

$$N = \frac{27(1497.4)}{4(142.282)^3}\frac{1}{(0.1875)^5} = 15.142$$

The solid height of the spring from Equation 17 is

$$H_s = 17.142(0.1875) = 3.2141 \text{ in.}$$

The Wahl correction factor should now be checked. The spring index $C = 2r/d = 6.67$. Then, from Equation 4, $K = 1.2245$. Since this is higher than the assumed value for K, the actual stress is:

$$S = 125000\left(\frac{1.2245}{1.15}\right) = 133{,}098 \text{ psi}$$

If this stress were higher than permissible, the problem would be reworked starting with a lower stress or a higher Wahl factor. In general, however, the stress assumed at the start is sufficiently below the yield point of the material that a percentage increase of the above nature does not warrant reworking the problem.

ANTIFRICTION B

Design of Ball and Roller Bearings

By Aaron Hochman

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ONE of the first considerations in the selection of antifriction bearings is determination of the appropriate rolling element design. Generally, for small high-speed applications with light load, ball bearings are the most suitable type, *Fig.* 1 *a, b,* and *c.* For large and heavily loaded applications roller bearings are usually most satisfactory. Roller bearings are distinguished by variations in construction of the roller to meet specialized requirements, *Fig.* 1*c, d, e, f, g,* and *h.* For example, roller bearings are well suited to relatively high speeds due to low-friction characteristics. Tapered roller bearings have high load carrying capacity radially, as well as axially in one direction. Needle roller bearings, *Fig.* 1*i,* are adaptable for variable and intermittent loads and are particularly suitable for applications where oscillation takes place. Spherical, concave, and convex roller bearings are specialized designs providing internal self-alignment of the rolling elements. Journal roller bearings are advantageous due to easy mounting.

Annular ball bearings are available in a variety of standard designs. Single-row radial types are produced in both Conrad and maximum (loading-groove) constructions. *Fig.* 1*j* and *k.* The Conrad type bearings otherwise known as the nonloading-groove type is the most popular of annular ball bearings and is most flexible as to use. In place of a loading groove or filling notch this bearing utilizes an uninterrupted race groove and contains the maximum number of balls that can be introduced by eccentric displacement of the rings. The maximum or filling notch type contains the maximum number of balls which can be introduced and still leave room for a retainer. This is accomplished by a groove cut in one side of both races through which the extra balls are inserted. The single-row, radial, Conrad type will sustain, in addition to radial load, a substantial thrust load. The counterpart maximum bearing, however, provides maximum radial load carrying capacity.

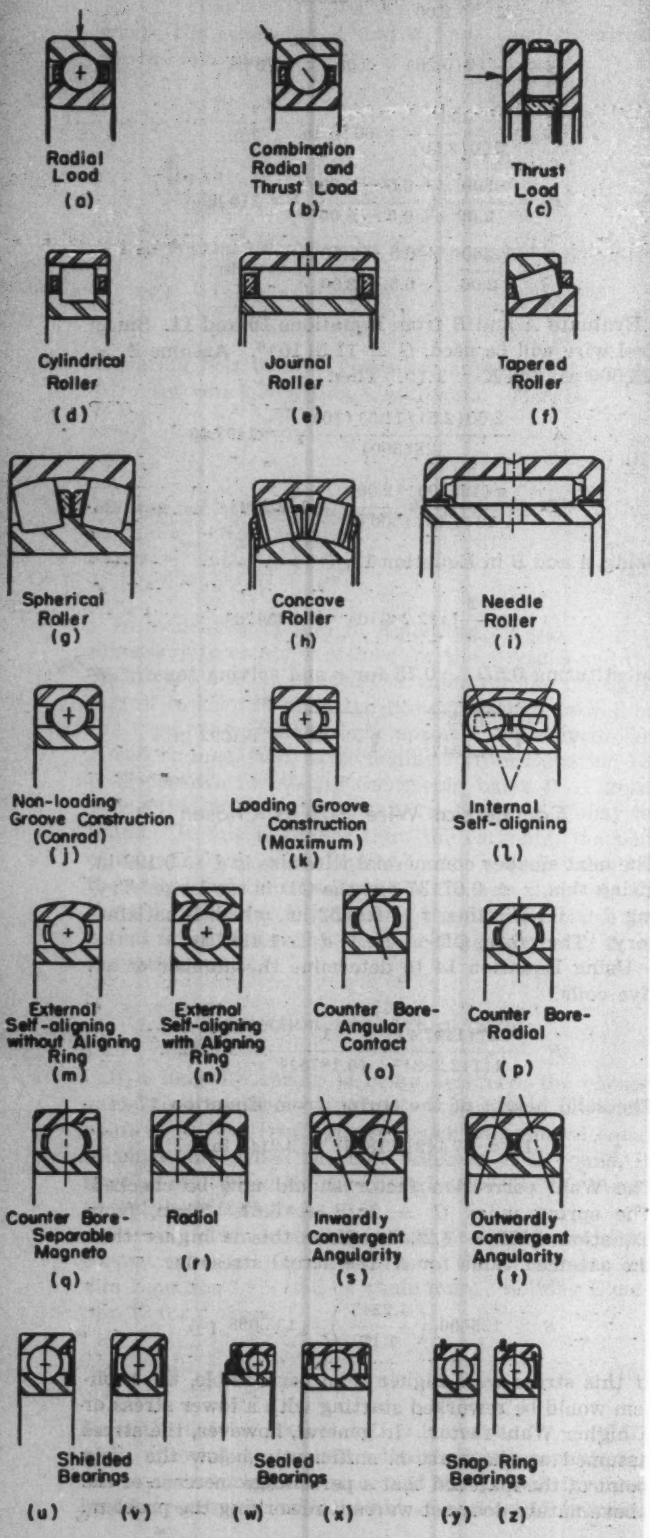

Fig. 1—Left—General types of antifriction bearings

This symposium is based on a series of papers presented at the Annual Meeting of the ASME in New York, Nov. 27-Dec. 2, 1949.

Both types are also available with extended inner rings or with the dimensions of the rings modified for sealing purposes.

Annular ball bearings are also provided in self-aligning types. Internal self-aligning types are constructed with the inner ring having two raceways similar to a double-row bearing *Fig.* 1*l*. The outer ring has a spherical inner surface so that balls and inner race can pivot about the center of the bearing. This enables the balls to choose a path on the outer race to compensate for misalignment between shaft and housing. External self-aligning types are available with or without aligning ring, *Fig.* 1*m* and *n*. When the aligning ring is used, inner and outer bearing rings are surrounded by a third separate ring with a spherical internal surface permitting the inner assembly to swivel in the outer aligning ring and thereby become square and true with the shaft and the assembly. When the aligning ring is not used the housing is grooved to accommodate the spherical outer ring of the bearing. External self-aligning bearings are normally furnished in single-row construction only.

Another variation of annular ball bearings are the angular-contact, counterbore, and magneto types, *Fig.* 1*o*, *p* and *q*. In the counterbore and angular-contact types, the outer ring has a deep shoulder on one side and shallow shoulder on the other, so that a maximum number of balls can be introduced when the outer ring is expanded by heat. The load line of the counterbore design has theoretically no angularity and by increasing the angle, as in the angular-contact designs, it is possible to increase the thrust capacity. These bearings are nonseparable.

Double-Row Construction for Thrust

The magneto, open, or separable types permit the outer ring to be separated from the inner ring and ball assembly. Bearing capacity is low, but due to the separable construction, the bearing offers certain advantages for easy mounting. Counterbored constructions provide thrust capacity in one direction only and for thrust capacity in two directions must be mounted in pairs.

Double-row annular ball bearings are provided in radial or outwardly and inwardly convergent angularity constructions, *Fig.* 1*r*, *s*, and *t*, with loading-groove and nonloading-groove design. These double-row bearings provide thrust capacity from two directions and reduced width comparable to a pair of counterbored, separable, or angular-contact single-row bearings.

All annular ball bearings have in common certain modifications of design. All types may be provided with one or two grease shields, *Fig.* 1*u*, *v*, *w* and *x*.

Another common modification is the use of a split ring snapped into a groove in the outer ring for positioning the bearing in the housing, *Fig.* 1*y* and *z*. This snap ring is often used in combination with grease shields or seals.

Usually, annular ball bearings are provided with a ball retaining cage, although some bearing types do not require one. Cages are bearing components which, while never participating in the carrying of the load, are nevertheless capable of exerting a vital influence on the efficiency of the bearing. In a cageless bearing the rolling elements contact each other in such a manner that their surfaces are liable to become damaged if the speed exceeds a certain limit. The chief function of the cage, therefore, is to keep the rolling elements apart, thus permitting the bearing to operate at high speed. In bearings of certain types, moreover, a cage is necessary to prevent the rolling elements from falling out while handling the bearing. In most standard types, the cage is usually of pressed steel, brass, or bronze. In large bearings, however, machined cages are preferred for reasons of manufacture and strength. Special-purpose cages are also made of nonmetallic materials.

Radial Bearing Clearance Critical

Another factor in selection, of extreme importance, is internal bearing clearance. Bearing clearance is the amount one bearing ring moves radially in relation to the other under a given small measuring load (radial clearances), or in an axial direction (axial clearances). For radial bearings, the radial clearance is of primary importance. Varying degrees of internal clearances are available depending upon the fit on the shaft.

If a ball bearing is to function satisfactorily, both the fit between the inner ring and the shaft, and the fit between the outer ring and the housing must be suitable for the application. Although a bearing must satisfy widely varying operating conditions, which determine the choice of fit, the tolerances for the bearing itself are standardized. The desired fits can, therefore, be obtained only by selecting the proper tolerances for the shaft diameter and housing bore. The selection of fit is dependent on the character of the load, the bearing dimensions, the temperature conditions in the bearing in operation, the heat expansion of the shaft and other parts, the design, and the requirements for running accuracy. The selection of tolerances for bearing housings is also influenced by the material and wall thickness of the housing. Finally, consideration must be given to the fact that the shaft deforms differently when its is solid than when it is hollow. The international ISA tolerance system provides a considerable choice of shaft and housing tolerances, which, when used with standard bearings, will give any of the desired fits from the

tightest to the loosest required.

It can be seen that bearing selection is by no means a simple matter. Each bearing manufacturer maintains a highly specialized staff of bearing engineers specially trained as application consultants. Harmonious collaboration between designer and manufacturer, and utilization of existing standards can only result in an economic and efficient product.

Selecting Bearings

By John H. Baninger

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TODAY machines are being built for higher speeds and are required to work to closer tolerances than ever before. In order to comply properly with these increased speeds and conserve the life of the cutting tools, the edges of which may be prematurely broken down by vibration or chatter, it has become necessary to incorporate a higher degree of precision and rigidity. It is common knowledge that the limits of plain sleeve bearings do not cover these requirements in every respect, and this inevitably leads to the increasing use of antifriction bearings not only in drive and feed mechanisms, and the like, but also on main spindles.

Bearings must provide permanently a high degree of rigidity under all loads and speeds, for this quality is essential not only to the accuracy and finish of the work produced but enables full life to be obtained from tools and the machine itself. For any heavy-duty machine using more or less the same construction for a spindle, this part, if mounted on ball bearings, must be somewhat heavier than if supported by roller bearings to obtain the same rigidity and consequent accuracy in the work produced. The reason for this statement is obvious—ball bearings have a curved, elliptical contact, while most roller bearings have a straight-line or rectangular contact. However, under spindle deflection the radial load in a roller bearing is not evenly distributed over the rollers but is transferred to a certain extent toward one end with the result of concentrating the load on a reduced area. This not only increases the pressure per unit area but also generates more friction and heat.

INSTALLATION: Three bearings for supporting a spindle or shaft should be avoided, if at all possible, mainly owing to difficulty in maintaining alignment resulting from distortion of a housing because of: (1) Nonuniform cross section; (2) localized heating; or (3) fastening of the housing to the base. Exception can be taken when using extremely long quill construction.

Bearings with a large number of balls have less radial deflection under the same load than bearings with the same outside diameter but having fewer balls of larger size. For spindle mountings, bearings with small cross section should be given preference to those having larger balls and, thus, larger cross section, thereby permitting the use of a stiffer spindle.

For a high-speed shaft on which a heavy thrust load is imposed, the bearing selected for resisting the thrust, if at all possible, should be mounted at the end of the shaft, thus permitting selection of a size of the heavy series having a bore smaller than the shaft without sacrificing shaft stiffness and thereby keeping the manufacturing cost low.

BEARINGS FOR HEAVY-DUTY SPINDLES: For rigid and accurate spindle mountings, the duplex type of bearing is most widely used because it is easier to produce two single bearings accurately than one double-row bearing. A duplex bearing has other advantages over a double-row bearing which leads to its preference. It can be preloaded much more heavily because the preload is applied after the pair or set is mounted on the spindle and installed in its housing. The preloading of a double-row bearing is limited simply because the balls can only be inserted by expanding and deforming the bearing outer ring. Obviously, it takes much more care and effort to assemble such a bearing without injury while inserting the last few balls of the second row.

When applying preload, the outer rings of a duplex bearing will expand a small amount and take up the clearance provided for easy assembly in the housing. Thus, a metal-to-metal contact between the bearing outside diameter and housing is obtained. This is absolutely necessary not only to secure the required spindle rigidity but also to maintain the shape of the bearing outer rings and distribute the pressure more uniformly onto the balls, thus maintaining the rated load capacity.

The adoption of a flange-type bearing for spindle-nose support is being favored more frequently as it permits the use of a straight-through mounting hole. Such a hole is much easier to machine and inspect, and can be obtained at considerably lower cost, which compensates for the higher cost of such a bearing.

BEARINGS FOR HIGH-SPEED SPINDLES: Ball bearings have proved to be the most satisfactory type, mainly because they are not as sensitive as other types of bearings to the application of the essential preloads. Furthermore, ball bearings operating under such conditions rotate more freely and, therefore, generate less heat, and the method of their lubrication is less troublesome.

Since the life of high-speed bearings is limited, depending upon uniform preload at all times, perfect alignment and proper lubrication, it is highly recommended that the quill type of construction be used which, from a replacement or service standpoint, permits very short interruption of machine operation, and thus is very economical.

For the past few years considerable study and experimentation have been devoted to spindles operating successfully at ultra-high speeds. Since the centrifugal force of the balls must be taken into consideration for bearing-load calculation, the required bearing size is determined by the outer ring ball track, while the inner ring ball track is relieved

of some of its load. Obviously, all the parts for such spindles must be made as close as possible to zero tolerances, especially the revolving parts. Therefore, both from the engineering as well as manufacturing standpoint it is often advisable to dispense with the bearing inner rings and grind the inner ball tracks directly onto the spindle.

The high-frequency motor has solved the drive for ultra-high-speed spindles in a most satisfactory way as the spindle itself can be built up as the motor armature, and its length can be kept rather short. By finishing the outside diameter of the spindle, including ball tracks and armature between centers, it is possible to obtain an absolutely concentric and dynamically balanced spindle. The bearing outer rings should preferably be of the deep-groove type. In order to use a one-piece, phenolic ball separator and still be able to assemble the two bearings, the snap ring shoulder should be on the outside of the spindle ball tracks and not in the bearing outer rings. The two bearings must be installed DF type and be spring preloaded, applying the pressure against the bearing outer ring.

Oil Lubrication of Bearings

By John P. Critchlow

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LUBRICATION has been a recognized necessity as long as there have been bearings but it has only been recently that investigations have been made into the reasons why certain lubricants were more effective than others for various bearing applications. These investigations have led to a better understanding of the functions of a lubricant in a bearing and have resulted in the development of highly refined and highly stable petroleum lubricants suitable for the lubrication and protection of all types of ball and roller bearings operating under almost any condition.

In general, there are five required functions of a ball or roller bearing lubricant:

1. Reducing friction between the sliding elements of the bearings
2. Reducing rolling friction or rolling resistance
3. Preventing rust and corrosion of bearing parts
4. Dissipating heat generated in and heat conducted to bearings
5. Preventing, insofar as possible, the entry of contaminating materials into the bearing.

The selection of a lubricant to overcome sliding and rolling friction, prevent rust and corrosion, dissipate heat and prevent, insofar as possible, the admittance of contaminating materials into the bearing will be governed by a combination of several major factors: (1) Operating speed, (2) operating and ambient temperatures, (3) operating load, (4) ambient atmospheric conditions, and (5) method of lubricant application.

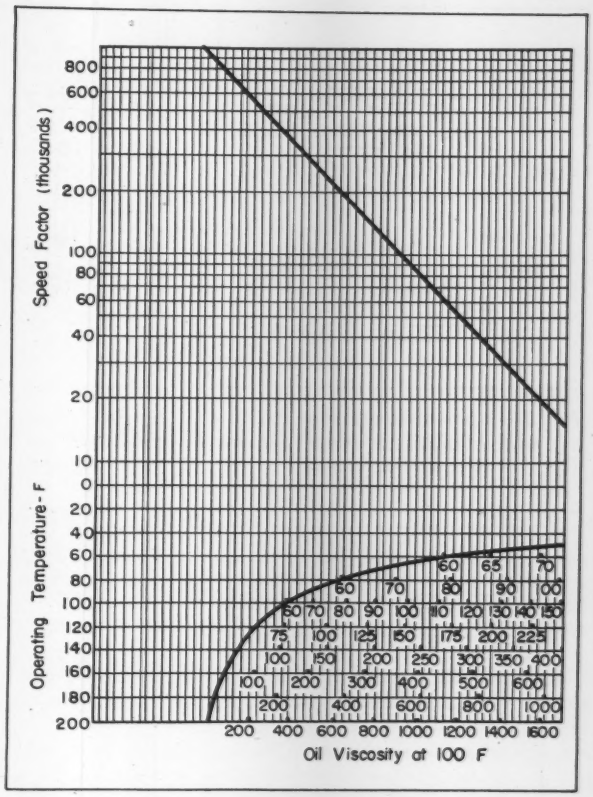

Fig. 2—Oil viscosity selection chart devised by New Departure Div., General Motors Corp. to determine proper oil for various operating conditions. Speed factor is equal to bearing bore in mm times rpm

Operating speed will, to a large degree, determine the viscosity of the oil to be used; "speed factor" being the term usually used to denote the speed of a ball or roller bearing for oil viscosity determinations. Speed factor is the product of the speed of the bearing in rpm and the bore of the bearing in millimeters.

Operating and ambient temperatures must also be taken into consideration when determining the proper viscosity of an oil for a given bearing application since the viscosity of a petroleum oil decreases with an increase in temperature. For high-temperature conditions, therefore, higher viscosity oils are required so that at operating temperatures they will have sufficient body to adequately perform their lubricating function.

Many bearings operate under temperature conditions below zero F. For such operations an oil should have a pour point below its lowest starting temperature. For abnormally low temperatures of below −50 F. it is usually necessary to use special lubricants developed for this type of operation.

Special consideration must be given to the selection of lubricants for bearings which operate under high-temperature conditions. A high operating temperature can be considered 175 F or over. Petroleum oils oxidize upon exposure to air and their rate of oxidation approximately doubles for each 20 F

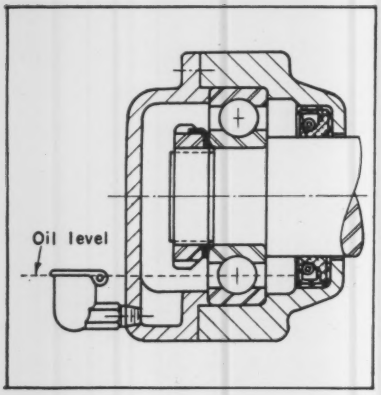

Fig. 3—Common oil-cup oiler for slow or medium-speed bearings requires frequent servicing

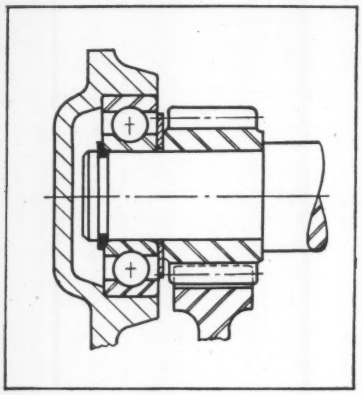

Fig. 4—Splash feed oiler good for gearboxes or other assemblies containing rotating parts

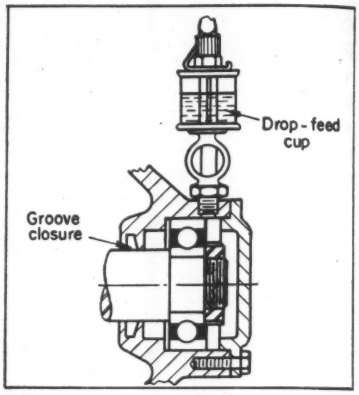

Fig. 5—Sight-feed oiler permits control of oil flow to bearing. Can be used for high or low flow

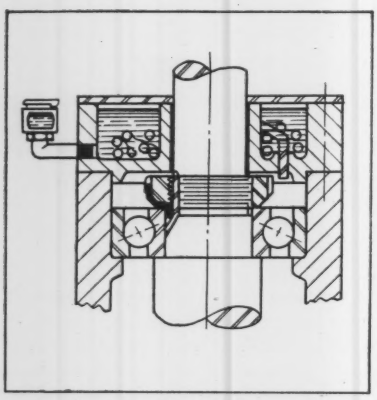

Fig. 6 — Wick-feed oiler good over wide variations in speed provides low flow where oil is not reused

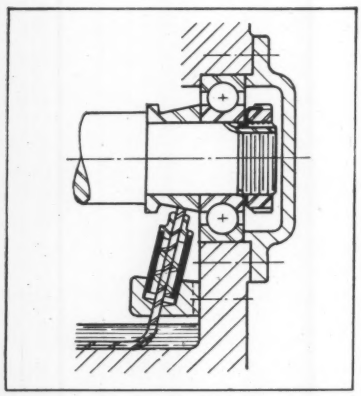

Fig. 7—Bottom wick-feed oiler in which oil flows with shaft rotation. Oil is drained to reservoir and reused

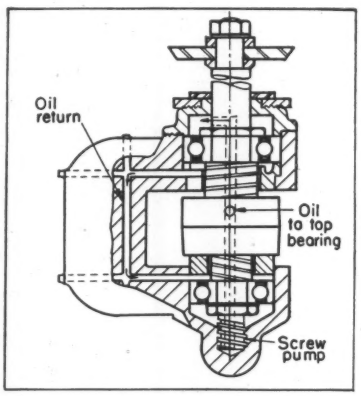

Fig. 8—Circulating oil system which pumps oil through shaft center to upper and lower bearings

rise in temperature. Oxidation of a petroleum oil results in its products of oxidation such as sludge, gums, varnishes, etc. These products, as has been previously stated, are detrimental to the efficient operation of a bearing. It is, therefore, obvious that for high-temperature operation careful attention must be paid to the ability of an oil to resist oxidation and only highly refined oils should be used.

SELECTION OF LUBRICANT: A chart, published by New Departure Div., General Motors Corp., which takes into consideration all of these factors and provides a suitable guide for determining the oil viscosity for various bearings operating under various conditions is shown in *Fig.* 2.

Example: To determine the proper oil viscosity for a 20-mm bore bearing operating at 10,000 rpm and 160 F, multiply 20 × 10,000 which gives a speed factor of 200,000. Reading across from 200,000 to the diagonal line and then down to the line marked 160 F it will be found that an oil having a Saybolt viscosity of 250 seconds at 100 F is recommended.

It will be noted that this chart does not cover all conditions; such would not only be impossible but also impractical. For points which fall outside the lower curve, *Fig.* 2, a "spindle" oil having a Saybolt universal viscosity of approximately 60 seconds at 100 F and viscosity index of approximately 100 is usually recommended. Applications involving operating temperatures below zero F and above 200 F, should be separately considered inasmuch as there are usually abnormal conditions present which require special study before a lubricant is selected.

The next variable that must be considered when selecting a lubricant is the atmospheric conditions under which the bearing will be operating. Dust, dirt, metallic particles, etc., can cause bearing failure in a very short time. The problem here, however, is more one of sealing than anything else. Mechanical sealing has its limitations and for extremely dusty conditions a grease is usually selected as the lubricant because of the additional sealing effect it affords.

Method of Application Important

The last factor listed as affecting the selection of a bearing lubricant is the method of lubricant application. This factor has been injected into the picture not so much because of its influence on lubricant selection but because of the important role it plays in supplying and maintaining the proper quantity of

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lubricant in the bearing. More often than not the lubricant is selected first and the method of application designed to suit the lubricant.

There are a few simple rules for designing or selecting a method of lubricant application which, if followed, should result in efficient lubrication.

1. The applicator or lubrication system should supply, at all times, an adequate but not excessive quantity of oil
2. If practical, it should be possible to visually check the quantity of oil being supplied or in the bearing
3. The applicator should be simple in operation and readily accessible
4. Where practical, the oiling system should be automatic.

LUBRICATION METHODS AND DEVICES: Some of the more common oil lubricating methods and devices for ball and roller bearings are outlined in the following paragraphs.

Oil bath constant-level oiler: Fig. 3 shows the common oil cup which can be located to maintain the proper oil level which, for slow or medium-speed bearings, is about the center of the lowest ball. This type of applicator is satisfactory for slow or moderate speeds but does require frequent attention.

Splash feed: This is a common method and is used in many gear boxes or other assemblies where rotating parts can be utilized to splash or throw oil into bearings. This system is not recommended for high speeds because too much oil is usually supplied the bearings. *Fig.* 4 shows a typical splash feed installation with an oil slinger.

Sight-feed oiler: Sight-feed oilers are designed to control the flow of oil to the bearing. They can be used for high-speed applications where the oil flow is extremely small, or they can be used on large circulating systems where oil flow is extremely large. Oil flow might vary from as low as one drop to several pints per minute. These devices have the advantage of being able to control oil flow as well as provide a means for observing whether or not there is oil flowing into the bearing. *Fig.* 5 shows a typical sight-feed oiler installation which can be used for high speeds.

Wick-feed devices: A common and efficient oiling device is the wick-feed oiler. There are probably more variations of this oiler than of any other type. They can be used with various modifications for a wide range of speeds. The oil flow through them can be controlled by the size and number of wicks. *Fig.* 6 shows a wick feeding device which can be used for high-speed bearings where the oil flow is low and the oil not reused. *Fig.* 7 shows what is known as a bottom wick-feed oiler. The oil feed with this type starts and stops with the shaft and the oil is drained to the reservoir and reused.

Circulating systems: The circulating system is, in general, the most efficient and also the most costly lubricating system. Where there are dozens of like bearings on a machine or machines operating continuously and under high-temperature conditions, it is almost imperative that such bearings be lubricated by a circulating system if efficient and continuous operation is to be maintained. High initial cost is more than justified by future economies. Circulating

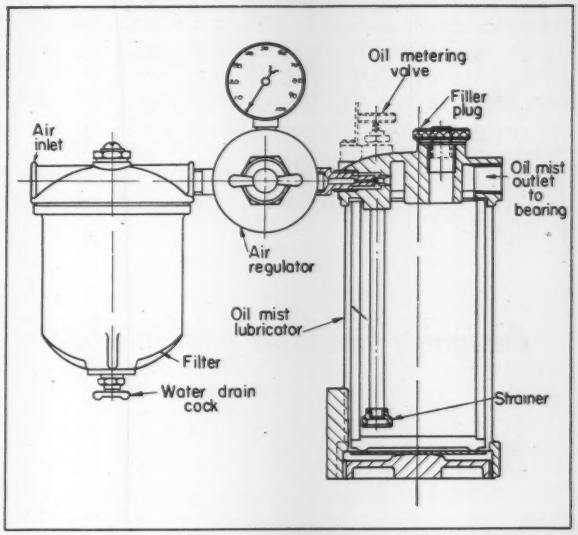

Fig. 9—Air filter, pressure regulating valve and atomizing unit of air-oil mist lubricating system. This method of lubrication is used almost exclusively on ultrahigh speeds

systems consist of an ample sump capable of supplying between two to three pints of oil per minute per bearing, and allowing approximately one and a half to two hours settling time, plus pumps, suitable filters, coolers, heaters, etc., for adequately cleaning the oil and returning it to the bearings at the proper temperature. Oil temperature to the bearings is usually between 120 to 140 F and return temperatures between 160 to 185 F. These large circulating systems have, of course, been designed to suit many types of machinery.

All circulating systems are not, of course, as large and complicated as that described above. A small system, such as shown in *Fig.* 8, is quite satisfactory and efficient. This system employs a screw pump which pumps oil up through the center of the shaft where it returns through the bearings.

Oil mist systems: With the advent of extremely high bearing speeds it has been necessary to devise some method for controlling the volume of lubricant fed to the bearing within narrow limits. Oil mist systems have been quite successful. These systems have been used on bearings operating at speeds of from 20,000 to 100,000 rpm and over. Essentially, they are designed to break up the oil droplets into a fine mist using air as the carrier. This principle has been used for years for lubricating steam engines and air tools. It was later adapted for use on high-speed grinding spindles and other high-speed bearing installations.

Mist Lubrication Required for Ultra Speeds

Several types of oil mist systems are in use today. Some are contained within the bearing housing and use an oil ring to carry the oil into the upper part of the assembly where it makes contact with an oil slinger which tends to atomize the oil.

Other systems use a separate unit apart from the bearing for forming the air-oil mist, *Fig.* 9. These

systems consist essentially of an air filter, a pressure regulating valve and an atomizing unit. They are particularly adaptable to high-speed spindles. These systems have the additional advantage of keeping the inside of the spindle housing under pressure thereby preventing the entrance of contaminants such as dirt, dust, grinding grit, etc. The air pressure on these systems is usually maintained between 10 to 20 psi.

Designing Housings and Spindles

By H. L. Blood

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IT is the aim of this article to shed some light on the less well-known but important points to be considered in the application of antifriction bearings. For example, if deflection and vibration are important considerations, the spring rates or stress-strain curves of the bearings should be known in order to decide on the best location for the bearings. The same information will be helpful if critical speeds are to be studied. To determine the proper fits and allowable tolerances for housings and spindles it is necessary to estimate bearing expansion under axial load and thermal expansion relative to the housing under operating conditions.

DEFLECTION OF SPINDLE AND BEARINGS: In order to reduce deflection between bearings, they are often mounted somewhat closer together than they would be if the only criterion were deflection at the load point. Spindle stiffness makes for smooth running and long life, by reducing unbalance and by maintaining better alignment of the bearings.

Spindle Deflection Calculations

When calculating the deflection of a spindle carried by angular-contact bearings, the angle of contact is sometimes neglected, and the spindle is considered as supported at the center of the bearings, as at *a, Fig.* 10. This assumption is incorrect, because it yields the same calculated deflection whether the bearings are back-to-back or face-to-face. Obviously, if two bearings are mounted face-to-face and located so that the areas of contact between balls and outer races lie approximately in a sphere, the bearings will be practically self-aligning. But if the bearings were turned back-to-back they would support the spindle much more rigidly. An assumption which agrees closely with the results of actual deflection tests on spindles of typical proportion is shown at *b, Fig.* 10. Here the spindle is considered as supported at the apexes of cones passing through the points of contact between balls and races. In other words, a bearing with a 15-degree angle of contact may be assumed to support the spindle at the intersection of lines passing through the center of each ball at an angle of 15 degrees from the face of the bearing.

SHAFT TOLERANCES FOR ROLLER BEARINGS: A slight interference fit has been found necessary for tapered roller bearings on rotating shafts, to prevent the inner race from creeping on the shaft and wearing the shoulder which backs the inner race. Wear of this shoulder would of course change the adjustment of the bearing.

Shafts for cylindrical roller bearings also are made a press fit in the inner races. For example, one manufacturer recommends in his catalog an interference of 0.0008 to 0.0022-in. for a 216 size. Some users prefer, by holding the shaft to close limits, to make the interference 0.0014 to 0.0022-in. for better control of the internal clearance in the bearing.

The internal clearance of cylindrical roller bearings used in gas turbines must be still more accurately controlled. Here the fits are held to extremely close limits by selective assembly.

SPINDLE TOLERANCES FOR BALL BEARINGS: In many ball bearing applications, clamping nuts are omitted and a tight fit is depended on to secure the inner race to the shaft. There is a growing tendency toward this practice in such applications as electric motors. Ball bearings, however, are not pressed on shafts as tightly as roller bearings.

Precision Work Requires Selective Assembly

Handbook and catalog tables of recommended fits should be consulted. The tables should correspond with the ABEC grade, that is, the tolerances of the bearings used. The tables should also show the type of service to which they apply so that allowance can be made for such factors as higher speeds, heavy or eccentric loads, or high precision. Such tables are often based upon practical tolerances for bearings and spindles, which add up to variations in fits which would be too wide for precision work.

Selective assembly is used to increase uniformity of fits in precision work. Experiments to determine the loosest permissible fit may be justified particularly if it is found that lapping spindles to fit each bearing can be avoided. Such individual fitting cannot be practiced in the shop without admitting harmful dust into the unwrapped bearings.

Ball bearings for high precision work usually are marked to show the eccentricity of each race and the high point, so that races can be assembled with their high points in line. The face runout of bearings, as well as the bending of the spindle due to clamping, of course, will depend upon how accurately the spindle locating shoulders are shaved, ground, or lapped, and on the squareness of the faces of nuts, sleeves, and slingers between which bearings are clamped. In precision work it is good practice to grind the threads and faces of nuts true with each other and to grind the threads on the spindle.

HOUSING TOLERANCES FOR ROLLER BEARINGS: In housings for cylindrical roller bearings the most common fit is a "tap fit," for example, 0.001 loose to 0.0004-in. tight. Such a fit avoids excessive re-

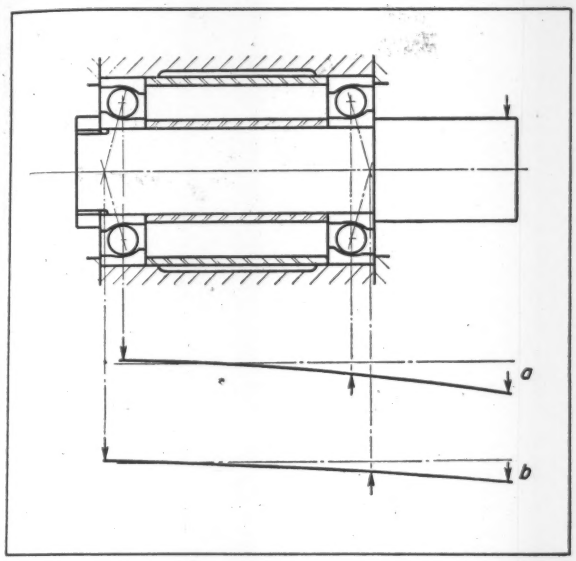


Fig. 10—Deflection of shaft and bearing under cantilever loading. Shaft is assumed to be supported at the center of the bearing, (a); shaft assumed to be supported at apexes of lines of contact in bearing, (b)

duction of the internal clearance which would occur if both housing and shaft had press fits. With this type of bearing it is not necessary for the outer race to slide in the housing to permit axial expansion of the spindle.

Mountings for Thermal Expansion

For taper roller bearings with stationary outer races, manufacturers recommend that the housings be made as close as possible to a metal-to-metal fit. If the outer rings revolve it is important they be mounted with the interference fit.

With either metal-to-metal or interference fits in a rigid housing, thermal expansion can build up tremendous pressure on the bearings. This has limited the speeds at which taper roller bearings can be run. Manufacturers of this type of bearing have been working for years to develop a mounting which would permit radial expansion without introducing looseness, and have arrived at the principle shown in *Fig.* 11. The cup of the rear bearing is carried in a sleeve, one end of which expands with the bearing and tends to fill the slight clearance between the sleeve and the housing bore. A clearance of from 0.001 to 0.004-in. on the diameter, depending on the size of the bearing and the requirements, is obtained by finishing a land on the sleeve after the cup has been pressed into the sleeve. The other end of the sleeve is a relatively tight fit in the housing.

HOUSING TOLERANCES FOR BALL BEARINGS: Fitting of housing bores to suit individual bearings should be avoided. Unwrapping a bearing for fitting before final assembly is almost certain to admit shop dust, a danger which cannot be stressed too strongly. Not only is such fitting expensive, but it has been found

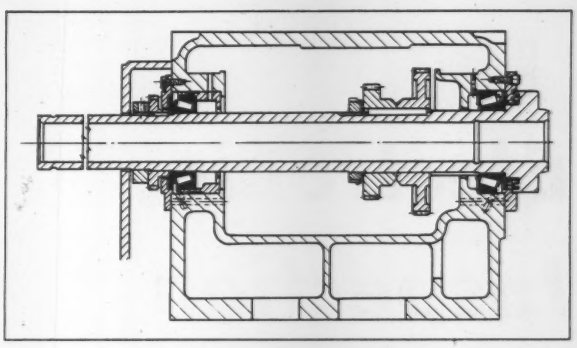


Fig. 11—Typical mounting to permit thermal expansion of bearings. Alternate designs shown above and below the horizontal bearing centerline

that the accuracy of a precision-bored or ground hole is apt to be destroyed by lapping, especially where it is necessary to work close to a shoulder.

Axial load or preload applied to an angular-contact bearing increases the angle of contact, both by compressing the balls and races and by expanding the outer race if it is not constrained. This consideration alone would indicate that the race should fit the housing snugly. If the clearance around a bearing is not large enough to allow the outer race to expand, heating will reduce the angle of contact, that is, the wedging effect produced by axial load may be increased many fold. This *does not* mean that the housing bore necessarily should be large enough to permit full expansion of a bearing which is not required to slide in the housing. It *does* mean that the difference between the operating temperatures of the bearing and housing should be considered in setting tolerances.

In the majority of ball bearing applications, it is important for at least one of the bearings to slide in the housing to accommodate axial expansion and contraction. A bearing cannot slide unless the clearance around it is nearly equal to the combined expansion from axial load and from temperature. Fortunately, it is often possible to check whether or not a fit is too tight by running a unit until operating temperature is reached, stopping it, and measuring the external load necessary to move the spindle lengthwise. In some designs it is necessary to loosen an end cap to make this check.

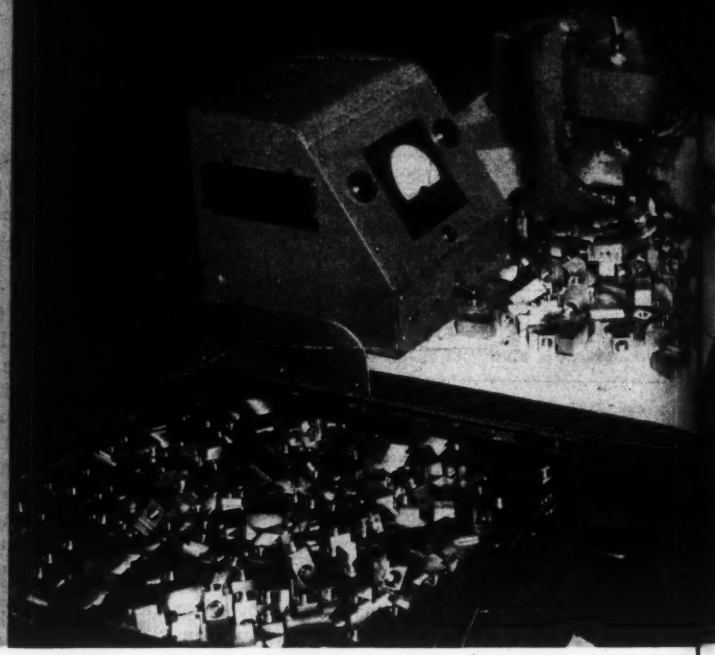
Reprints Available

The article, "Engineering and Shop Relationships" by Harold A. Bolz, published in the January issue, is available to readers in reprint form. Single copies will be mailed upon request, with the compliments of MACHINE DESIGN. Quantities are obtainable at a nominal price of twenty cents a copy, payment to be included with order. For orders to be delivered in Ohio, state sales tax should be added. Please address the Editorial Department, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Electronic Inspection Machines

. . . accurately sort products for size

By Alexander Maxwell
Vice President, Engineering
The DoAll Co.
Des Plaines, Ill.



SEVERAL years ago when a "tenth" was considered close work, the output of screw machines was acceptably uniform. Today, when a millionth is not only recognizable but obtainable, the same machines are observed to have a wide range of latitude. To obtain uniformity on production runs averaging ten thousand units a day, automatic inspection has proved its worth. The machine does the sorting and delivers the product classified into size ranges.

As an electronic segregator will identify variations of a millionth of an inch, it can isolate and classify the output of a machine into any number of designated departures from base tolerance. It is to the advantage of everyone to have spacers, shims, studs, caps and sleeves in one engine consistent. A wide range of sizes is permissible as long as consistency is maintained.

Making high-speed inspection equipment has already risen from a custom operation to big business. Yet each inspection machine must be designed to perform a specific sequence of functions. It is still custom work because the maker designs, builds and delivers one machine at a time. It was left to the Arlin Products Laboratory of Detroit to develop a master model which could be quickly modified to accommodate whatever job materialized. The idea of module or unit construction is employed.

Key to the setup is a hand-fed device, *Fig.* 1, which can be adjusted with the ease of a micrometer and will automatically inspect anything capable of passing through the jaws of the gage head. Incorporating this device into a high-speed machine involved only the development of handling mechanisms. Inspecting a ball bearing, stamping or spark plug is simple. The problem is making a mechanism to get it under the gage head, then out again.

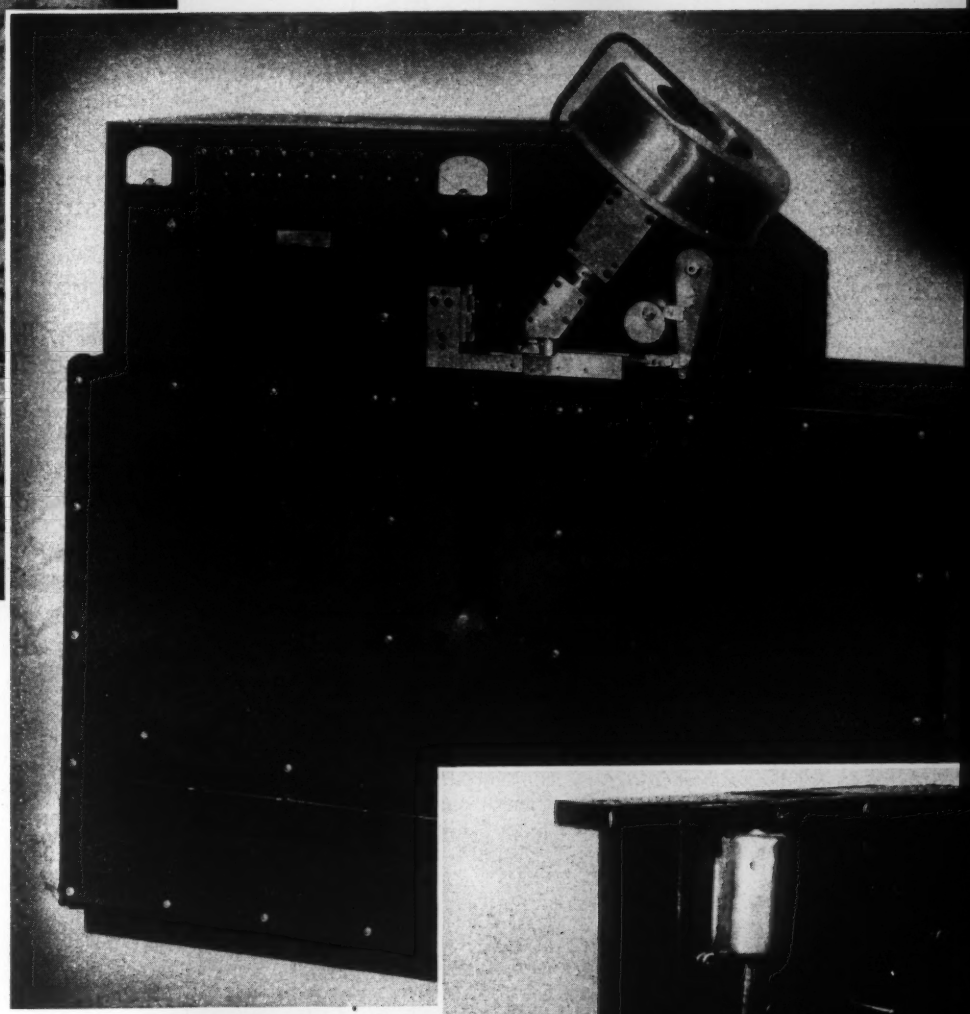
A simple and foolproof means of sorting by opening and closing a gate in a split second was required. By amplifying the short stroke of a solenoid with levers, the problem of gate operation was solved. Current applied for a period as brief as 1/60-second is sufficient. Allowing for lag, inertia and spring return, the gate can be actuated 55 times a second. As the gate never moves more than twice in one second, the mechanism is adequate.

Each solenoid is small and can be fitted close to the job. On the earlier machines, and all the hand fed ones, solenoids are employed only to actuate the

Fig. 1 — Left — Hand-fed selector for short-run gaging

Fig. 2—Below—Automatic inspection machine of the type used by the automotive industry for continuous run inspection of just one product. This one separates spacers into 8 classifications of product size

Fig. 3—Bottom—Closeup of solenoid-operated segregator gate unit utilizing boiler plate construction. Exploded solenoid is shown in foreground



sorting gates. There, the action is controlled by the gage head which is coupled to an electronic bridge. Any unbalance in the circuit directs current to one of several solenoids, each governed by a thyratron. As the piece being inspected is pushed under the gage head, it fires a thyratron. When the piece drops down the chute, a solenoid opens the gate to the proper pan. An automatic machine for sorting spacers into eight size channels is shown in *Fig.* 2.

On the simpler machines the gates are interleaved and remain static until the gage head responds to a different reading. When one moves it reshuffles the others to open a new channel. On the more involved segregators, each gate has a spring return. Rejects drop through without actuating any gate. When the proper thyratron is fired, any one of three, six, or even dozen gates goes into action, staying open just long enough to catch the object and direct it into the desired channel.

Delicate and responsive as the mechanism is, it must be sturdy because of high-speed operation. Segregator chutes are boiler-plate construction, *Fig.* 3, the gates usually being faced with

brake lining because of the severe service.

With the sorting end of the segregator operating at high speed, the next step was to increase the speed of feeding. Ordinarily a motor-driven hopper, gravity feed and cam-operated ram are employed, *Fig.* 4. Delivery is governed entirely by the shape, size and relative complexity of the piece being measured. On ball bearing retainer rings, each must be grasped by mechanical tongs, placed on a mandrel and rotated, gaged and ejected to the chute. Roller bearings need only to be slid along, one pushing another, a ram pushing the last one. Spacers, beads, pins and stampings require a little persuasion. A solenoid-operated ram was the first improvement replacing motor, belt, countershaft and cam.

The most recent design of segregators has every movement actuated by a solenoid, *Fig.* 5. In this unit taper pins are inspected, each ½-inch long and all to be of identical size. Inspection consists of inserting each pin, small end first, into a tapered ring gage. Pin length and degree of taper are measured.

Pins from a hopper pour down a feed chute or tube. A solenoid removes the bottom pin and places it on an anvil. If the pin emerges from the chute with small end down it drops through a tapered slot in the anvil and goes on its way. If it emerges with large end down it sticks in the slot. Then the anvil passes under a gage head. If a pin is present a solenoid is actuated and pushes the pin off and into a reversing cavity.

Baffle Turns Pins to Correct Position

When the pin strikes a baffle, it is turned end for end and comes out small end first onto a pin carrier. This carrier drops until in line with the ring gage.

Coupled to provide an extra long stroke, a pair of solenoids pushes a ram, shoving the pin into the ring gage. The protruding small end of the pin touches a piston, pushing it until a collar contacts a reed pendulum and also moving the armature of the measuring solenoid. The reed actuates the measuring button of the gage head which in turn passes on the information to the thyratrons, opening the proper gate of the segregator chute. As the gate opens the pin carrier rises to the eject position, the knock-out solenoids push the pin out the ring gage, down into the cavity under the carrier and thence into the segregator chute.

All this happens in a matter of seconds. Action is entirely automatic, good pins are separated from bad with positive finality.

Automatic inspection is accepted by shop men with good grace. They know the machine is fair and that it acknowledges good work just as impartially as it rejects the bad. It also performs quickly, often detecting rejects within minutes after a run is started. This provides an opportunity to correct the setup before any quantity is run.

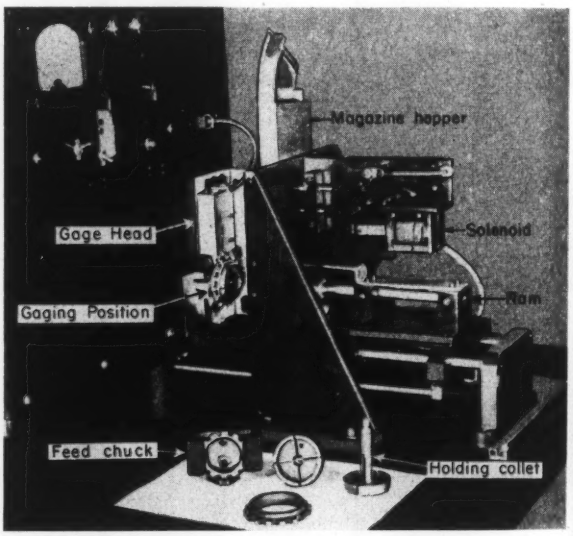


Fig. 4—Above—Closeup of feed mechanism of segregator designed to gage the concentricity of roller bearing retainers. It is driven by combination of motor and solenoid

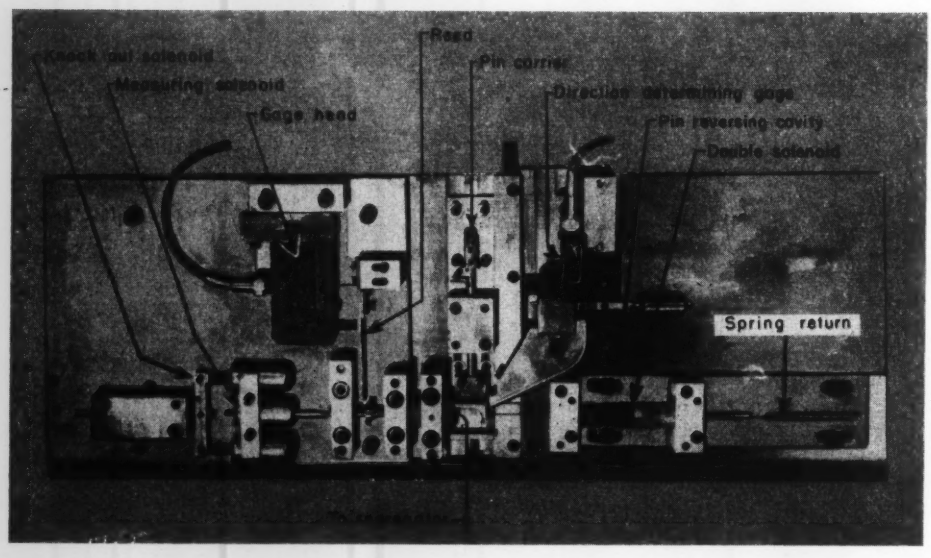


Fig. 5—Left—Pin gaging segregator element entirely solenoid operated

Torque Capacity of Splined Connections

By W. R. Leopold
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PROPER design criterion for splines must be based upon the type and quality of spline as well as the operating conditions to be encountered. For instance, if very close tooth tolerances are maintained and a shrink fit is incorporated during assembly, it is evident that the assembly is essentially a solid shaft and shear stress through the spline teeth, rather than tooth compressive stress, would be critical. It is common practice to allow this shear stress to equal 60 per cent of the ultimate tensile stress or, in fairly ductile materials, 60 per cent of the yield stress.

In most cases, however, ease of assembly and servicing dictates that shrink fits on splines be eliminated in favor of loose or semitight assemblies. Even though in these cases high control of tooth tolerance is maintained, slight errors in tooth spacing still occur and the criterion which must be considered, and which will dictate design, is tooth wear or chafing.

Chafing, it is recognized, is a function of motion and loading and can induce rapid parts failure. For this reason, consideration must be given to the variations in torque imposed upon the spline in choosing the value of contact stress to be maintained. It is evident that spline contact stress must be maintained at a lower level if the torque is pulsating.

Experience has shown that with ordinary crankshaft steels of approximately 100,000 psi yield stress in reciprocating engines subject to rapid torque variations, spline contact stress, or bearing pressure, should be maintained at approximately 4000 psi for loose fit splines, if chafing is not to result. On the other hand, steady torque inputs, as obtained in electric motors and turbines, allow several times this value to be used for contact stress. In some cases, values as high as 60,000 psi have been used satisfactorily with ordinary crankshaft steels. It will be found in general that to carry any load, or for stability, it is seldom necessary to have the width of spline longer than its pitch diameter.

Stub-tooth involute splines are commonly used for splined couplings. Considering then that the torque a splined coupling is capable of transmitting is a function of the spline pitch diameter, the allowable contact stress and the tooth form, the following equation may be written:

$$T = S_c\, h\, b\, N \frac{PD}{2}$$

where T = torque, inch-pounds; S_c = compressive bearing stress, psi; h = working depth of spline tooth, inches; b = width of spline, inches; N = number of spline teeth; and PD = pitch diameter of spline, inches.

For the stub tooth involute spline, $h = 1/DP$, where DP = diametral pitch = N/PD. Substituting $h = PD/N$ in Equation 1

$$T = k\ (PD)^2\ b$$

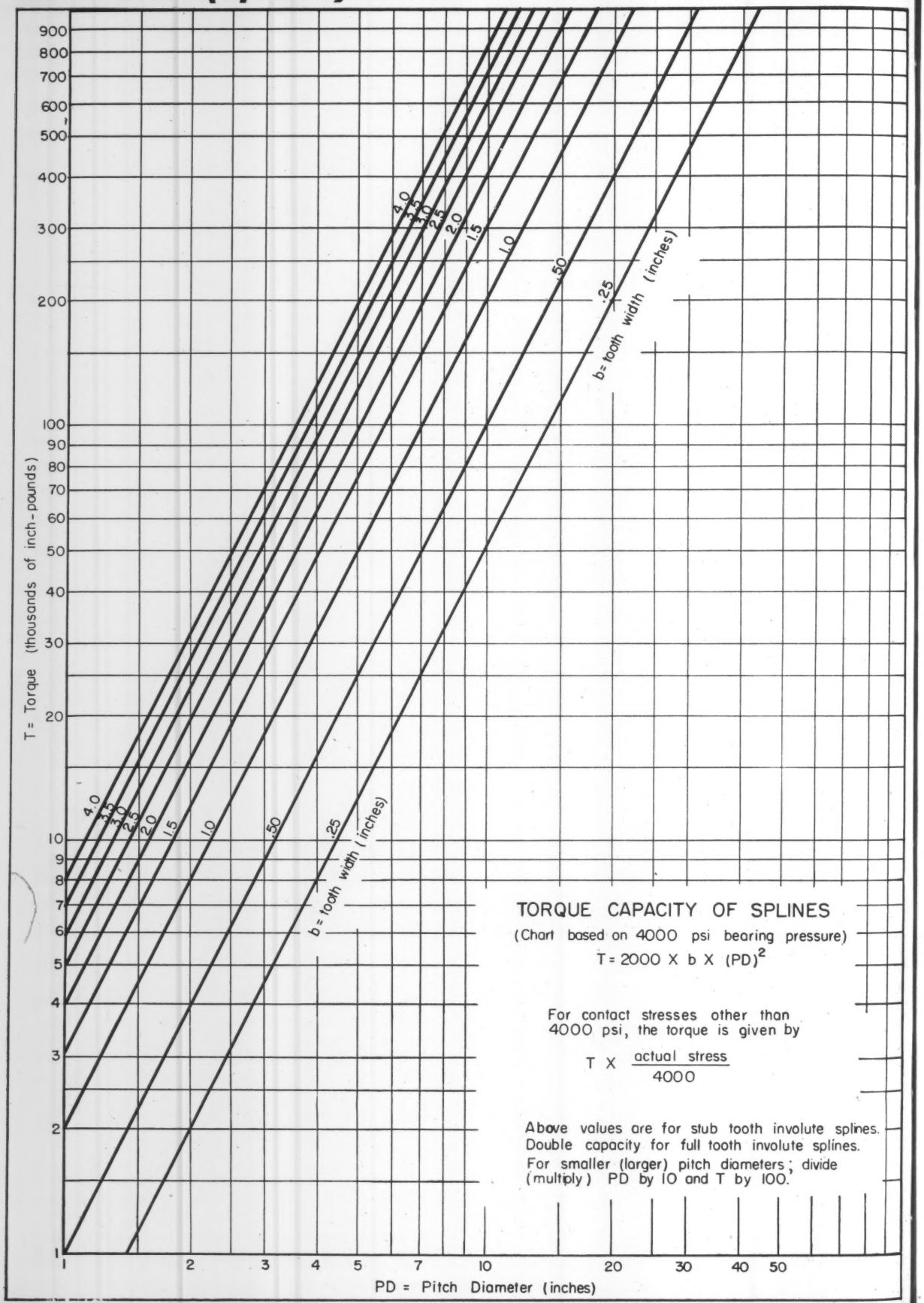
where $k = S_c/2$. It should be noted that tooth angle does not appear in this equation, the torque capacity of any given form of spline being a function only of its pitch diameter and width.

The chart on the following page is based upon a contact stress of 4000 psi but can easily be modified directly, as shown, to incorporate any other desired stress level. To illustrate its use consider the following example.

EXAMPLE: Given: PD = 5 inches, and torque to be transmitted = 50,000 in-lb, find spline width. At the intersection of 50,000 psi and 5 inches PD on the chart, the width of spline required for 4000 psi contact stress is given as 1 inch.

Material for this data sheet was compiled for the Wright Aeronautical Corp.

Data Sheet (Splines)



TORQUE CAPACITY OF SPLINES

(Chart based on 4000 psi bearing pressure)

$T = 2000 \times b \times (PD)^2$

For contact stresses other than 4000 psi, the torque is given by

$$T \times \frac{\text{actual stress}}{4000}$$

Above values are for stub tooth involute splines. Double capacity for full tooth involute splines.

For smaller (larger) pitch diameters; divide (multiply) PD by 10 and T by 100.

NEW PARTS AND MATERIALS

For additional information on this new equipment see Page 161

Hopper Feeding Unit

Automatic, self-contained model H-100 hopper feeding unit is especially adapted to feeding of flat cylindrical work such as washers, nuts, bearing races, and special stampings. Selector ring, driven by fractional horsepower motor, rotates through work which is selected and fed from underside of ring in one operation. Feeder can be used with assembling presses, automatic welding machines and many second operation machines. Manufacturer: Feedall Machine & Engineering Co., 29 Elm St., Willoughby, O.

For additional information circle MD 1 on Page 161

Vertical Speed Reducers

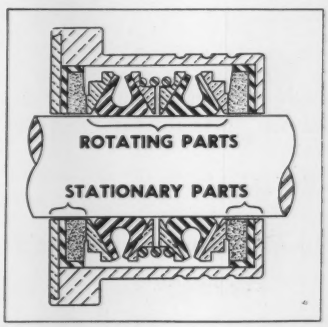
Because they are capable of withstanding externally applied loads on gear shafts, whether extended upward or downward, types NU and ND vertical shaft worm gear speed reducers are particularly suitable for driving such equipment as agitators and mixers. They are also usable in conjunction with supplementary low-speed spur gear drives without outboard bearings.

Worm threads are formed integrally with shaft which is journaled in antifriction bearings, and face type seal prevents leakage at worm shaft extension. Worm gear is solid bronze in sizes 100 and smaller; larger sizes employ flanged rim construction. Oil level sight window in cast gray iron housing permits check of oil.

Gear shafts are supported by tapered roller bearings with capacity to carry heavy external radial loads on shaft extensions, as well as up or down thrust loads. In the size 50 unit, all bearings are splash lubricated, and on larger sizes positive pressure lubrication is provided. Seven sizes from 50 to 500 are supplied in each type. Manufacturer: Cleveland Worm & Gear Co., 3265 E. 80th St., Cleveland 4, O.

For additional information circle MD 2 on Page 161

Mechanical Shaft Seal



Leakage of gases and liquids around rotating shafts can be eliminated by these antifriction mechanical seals for shaft sizes from ¼-in. and up. Moving parts rotate with shaft and effect positive seal between lapped metal rings and self-lubricating microfine graphite rings. There is no scoring or galling of shaft as no friction is introduced at any point on shaft. Seal is fitted to the shaft by flexible rings, and, end play, chatter, etc., do not affect sealing faces. Adequate clearance in seal housing allows limited amount of shaft misalignment or distortion. As fluid pressure increases or decreases, unit pressure between sealing faces automatically increases or decreases. Standard Model M marine type seal is also available with flush connection and with flush connection and abrasive excluder. Manufacturer: Syntron Co., Homer City, Pa.

For additional information circle MD 3 on Page 161

Stainless Steel

Having strength and hardness of high carbon spring steels, 17-7 PH precipitation-hardening stainless steel has corrosion resistance closely approaching that of 18-8 stainless steel. It is usable for springs, pressure tanks, diaphragms and disks, conveyor parts, spring clips, washers and similar parts. Yield strength in compression is equal to or higher than yield strength in tension. Alloy is available in soft temper strip, sheet and plate; hard temper sheet

and strip; and hard temper and extra hard temper wire.

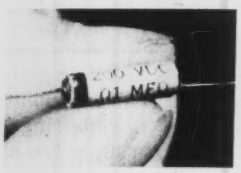
In soft temper condition, alloy can be severely formed or drawn and can be welded by resistance, metallic-arc and inert gas shielded-arc methods. After fabrication, its full strength and hardness are developed easily. Soft temper sheets when fully hardened have tensile strength 185,000 to 205,000 psi, yield strength 160,000 to 190,000 psi and hardness Rockwell 40 to 45 C.

Hard temper sheet and strip have fabricating properties equal to type 301 full hard temper stainless steel. In this condition, material can be punched, blanked, flanged and dished to moderate degree. Tensile strengths over 255,000 psi and Rockwell hardnesses over 51 C are developed; even higher strengths and hardnesses are possible in very thin gage material.

In wire form, alloy can be wrapped on its own diameter and develops properties similar to those of carbon steel music wire. After hardening, it has tensile strength of 260,000 to 345,000 psi, yield strength 250,000 to 340,000 psi, hardness Rockwell 50 C and up, and proportional limit in torsion 150,000 to 180,000 psi. Wire is also available mill treated at 850F; in this condition it is designated extra hard temper. Manufacturer: Armco Steel Corp., Middletown, O.

For additional information circle MD 4 on Page 161

Small Tubular Capacitors

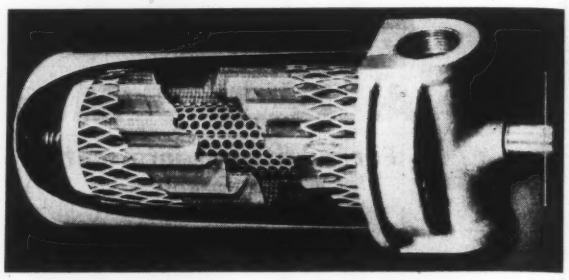


Usable at temperatures to 212 F without drips, small paper-case tubular capacitors, type P85, have high initial resistance which is recoverable upon heating. Dielectric strength is maintained at elevated temperatures. Paper section is Aerolene-impregnated, and capacitor is sealed with Duranite. Resulting rock-hard paper-cased tubular element is heat and humidity resistant. Manufacturer: Aerovox Corp., New Bedford, Mass.

For additional information circle MD 5 on Page 161

Liquid Line Filter

Operating equally well in any position, this Synclinal filter has no moving parts and can be inserted into any pipe line carrying noncorrosive liquids. Capacities are 5, 8, 10, 20, 30 and 50 gpm. Greater capacities can be obtained by multiple installation. Cast aluminum head and steel housing are designed for maximum working pressure of 125 psi. Standard model is equipped with 100-mesh wire cloth; where other gages are required, filter elements are available in sizes from 30 to 200 mesh. By removing one hand nut, filter can be disassembled, cleaning being



accomplished without disturbing pipe fittings. Manufacturer: Marvel Engineering Co., 625 W. Jackson Blvd., Chicago 6, Ill.

For additional information circle MD 6 on Page 161

Self-Priming Pump

Equipped with manual by-pass control valve to permit easy regulation of pressure and flow rate, this model ESP stainless steel self-priming pump is recommended for pumping corrosive liquids, chemicals, drugs, foods and pharmaceuticals. It can be obtained in five sizes: 3, 5, 10, 20 and 30 gpm at 0 psi. All sizes can be supplied as individual units or as complete pump assemblies, direct or belt driven. Manufacturer: Ertel Engineering Corp., 22 Front St., Kingston, N. Y.

For additional information circle MD 7 on Page 161

Variable Transformer

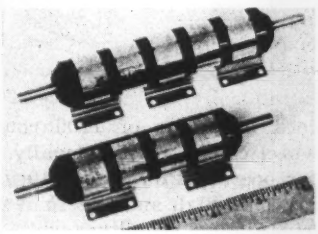
Redesigned types 116 and 216 Powerstat variable transformers incorporate numerous improvements but retain standard mounting dimensions to conform to existing panel layouts. Type 116 operates from 115-v 50/60-cycle source to deliver 0 to 135 v, 7.5 amp; and latter type has output of 0 to 270 v, 3.0 amp from 230-v 50/60-cycle single-phase current.

Modifications include use of die-cast aluminum terminal box on cord-plug models, heavy terminal board of phenolic plastic, better arrangement of solder-screw terminals, and barriers between terminals to reduce short circuit hazards. Other improvements

incorporated in cord-plug models are new fusing arrangement and polarity identification for requirements involving ground loads. Manufacturer: Superior Electric Co., Hannon Ave., Bristol, Conn.

For additional information circle MD 8 on Page 161

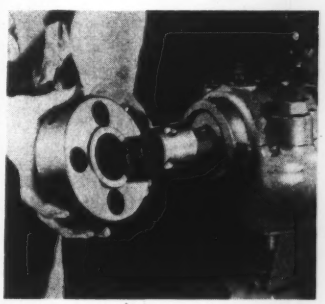
Miniature Speed Changers



Several hundred ratios between 1000:1 and 750,000:1 are attained by adding one or two additional gearing sections to standard three-section miniature speed changer. Input speeds as high as 50,000 rpm and output torques up to 2 lb-in. are permissible. Very high ratios in hobbed gear and 'zero backlash' construction can be furnished at reduced torque rating. Weights of four and five-section units are approximately 6 and 7 oz respectively. Manufacturer: Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.

For additional information circle MD 9 on Page 161

High-Speed Shaft Coupling



Transmitting up to 120 hp at 3550 rpm, this Magic-Grip coupling is available in two bore sizes, 5/8 and 2 1/8-inch. Coupling consists primarily of two cast-iron disks with tapered bores, rubber covered tubes assembled on studs, split tapered bushings and two setscrews for each disk. Four drilled recesses in bushing accommodate off and on positions of setscrew driving holes of coupling. Bushing holes are offset so that when setscrews contact them, force is applied in direction to drive tapers of two pieces either tighter or looser, depending upon whether screws are placed in "on" or "off" positions. Manufacturer: Allis Chalmers Mfg. Co., Milwaukee, Wis.

For additional information circle MD 10 on Page 161

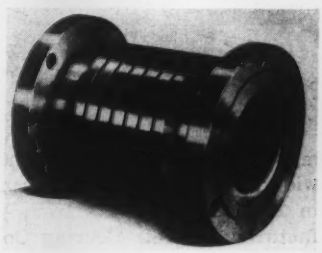
Magnetic Transductor Material

Having very narrow rectangular hysteresis loops, Hipersil and Hipernik V materials are especially suited for electronic application such as magnetic amplifiers, saturable reactors, and new types of contact rectifiers. Available in several lamination thicknesses for various frequency and response requirements, materials can be supplied in continuous toroidal or rectangular and butt-joint cores.

Preferred grain oriented Hipersil cores, which are not sensitive to mechancal or magnetic shock, are obtainable in either continuous or butt-joint form in sizes ranging from a few ounces to several hundred pounds. Hipernik V 50-per cent grain-oriented alloy is supplied in toroidal cores of 0.002 or 0.005-in. lamination thicknesses. Core is completely enclosed in form-fitting Micarta case to protect against shock and strain during winding. Manufacturer: Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

For additional information circle MD 11 on Page 161

Pipeline Expansion Joint

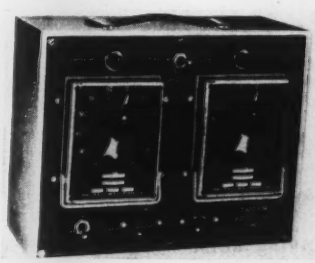


Axial, offset and radial motion control in high pressure piping systems to 1000 psi is afforded by Flexoniflex line of expansion joints. They consist of corrugated bellows type sections of stainless steel or other alloys formed within integral control rings and end sections. Integral construction of control rings permits unit to withstand extremely high pressures.

Standard joints are made with single or multiple plies, can be lined or unlined and are available in sizes from 5/8-in. ID. Temperature range for stainless steel construction is from subzero to 1400 F, and this upper limit can be exceeded with use of special alloys. Manufacturer: Chicago Metal Hose Corp., Maywood, Ill.

For additional information circle MD 12 on Page 161

Recycling Timer

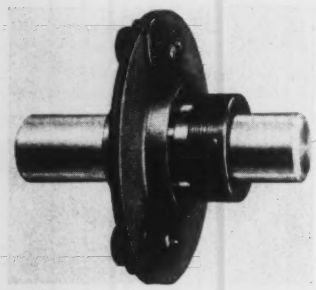


Two individual timing elements, each able to control a specific operation, are accommodated in a single housing by this Tandem recycling timer. When timer dials are set to respective time intervals required, each cycle of operation will follow the other continously in regular sequence. Unit will maintain this sequence without adjustments until new time intervals are required. Control cabinet measures 11½ x 9 x 7 in. and contains two sockets into which timing elements are plugged so that they control single-pole double-throw load relay. Contact circuit of this relay is unpowered, permitting application of particular

voltage and current necessary for test or production. Load relay contacts are rated 20 amp at 115 volts ac, noninductive. Applications include control of machinery, apparatus life testing, conveyor system control and laboratory use. Manufacturer: Industrial Timer Corp., Newark, N. J.

For additional information circle MD 13 on Page 161

Lightweight Flanged Ball Bearing

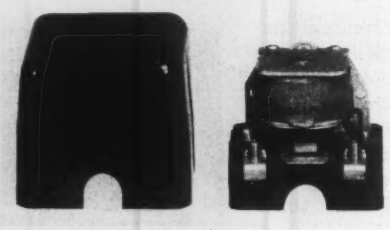


Designed primarily for light-duty, slow-speed antifriction bearing applications, Flangette ball bearing power transmission unit features light weight, sealed-in lubrication and ease of installation. It consists of two pressed steel stampings which form housing and standard self-aligning wide inner ring type ball bearing. Unit is available in 18 sizes for shafts from ½ to 2 3/16 in. Manufacturer: Fafnir Bearing Co., New Britain, Conn.

For additional information circle MD 14 on Page 161

Voltage Type Accelerating Relay

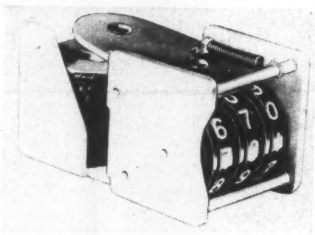
Designed specifically for starting single-phase, capacitor-start and capacitor-run motors, CR1057-J relay is particularly applicable where adverse atmospheric conditions exist or where it is desired to have remote control which can be incorporated in explosionproof case. Relay can be furnished with or without cover and can be wired from top or bottom. All parts are corrosion resistant. Relay is accurately calibrated to pick up at predetermined voltage, thus



taking start winding out of circuit at desired speed. Extremely wide differential between pickup and drop-out voltage gives positive operation of control despite wide variations in line voltage. Contact rating is 50 amp at 115 v and 30 amp at 230 v. In normal operation, contact handles start-winding current only. Relay meets all Underwriters' Laboratories specifications. Manufacturer: General Electric Co., Schenectady 5, N. Y.

For additional information circle MD 15 on Page 161

Electromagnetic Counter



Actuated through electromagnets, three or four-digit magnetic counter can be connected in vacuum tube plate circuits or operated by any contacting device. Additive or subtractive counter wheels record maximum of 1200 counts per minute. Each wheel can be reset manually. Counter can be wound for operation on 24 or 110 volts, ac or dc. Measuring 1 in. high and less than 2 in. deep, unit weighs 2 oz. Figures are either white or fluorescent on black; die-cast case is finished in black lacquer. Manufacturer: Abrams Instrument Corp., Lansing 1, Mich.

For additional information circle MD 16 on Page 161

Pressure-Vacuum Switch

Recommended industrial applications of this pressure and vacuum switch include use on indicating and actuating devices for fluid, air pressure and vacuum systems. Switch illustrated can be made to operate either normally open or normally closed, with pressure settings of 0 to 50 psi. Maximum operating pressure can be as high as 200 psi. Unit can be used at temperatures to 300F and in systems using lubricating oil, air, brake fluids, fuel oils, etc. Switch can be supplied with two insulated terminals or with one terminal grounded. Manufacturer: Fasco Industries Inc., Rochester 2, N. Y.

For additional information circle MD 17 on Page 161

Protective Plastic Coating

Formulated of vinyl resin, this protective coating is recommended for service over operating range of −40 to 160 F, either wet or dry. It is resistant to alkalies and mineral acids; is insoluble in alcohols, greases, oils and aliphatic hydrocarbons; and has low permeability to water vapor and low water absorption. It is therefore particularly effective in applications where metal is subject to deterioration from chemical or moisture attack. Since it is nonflammable and imparts neither taste, odor nor toxity, it can be used on surfaces which come in contact with foods.

Material develops excellent adhesion to relatively smooth surfaces without heat curing and air-dries

JOHNSON BRONZE

SLEEVE BEARING DATA

CAST BRONZE

JOHNSON BRONZE

SLEEVE BEARING DATA

Selecting the Alloy

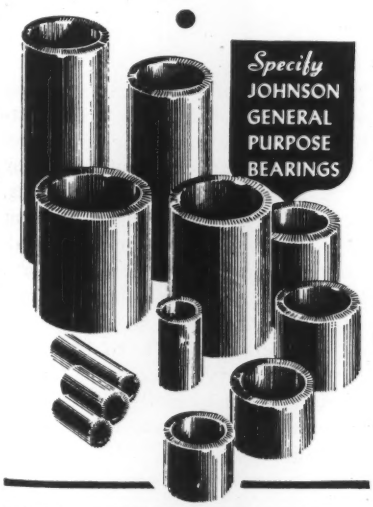
The many and various applications for sleeve-type bearings make necessary the availability of a variety of bearing metals possessing many distinctly different properties. Each particular bearing metal must be best suited for those conditions of service wherein its outstanding characteristics will be of greatest advantage. Accordingly, in the selection of a bearing material it is necessary that the service conditions and the destructive forces on the bearing be analyzed first and the bearing material be then selected for each specific application.

The first step is to accumulate accurate operating data such as speeds and loads . . . whether constant or intermittent . . . method of lubrication; the presence of acid, harmful chemicals, gases, grit or dust; the type of shaft to be used.

All sleeve bearings operate in direct contact with the shaft until the creation of the necessary film of lubricant. Consequently, the following physical properties govern the suitability of a bearing metal: (1) Plasticity; (2) Ability to Resist Wear; (3) Coefficient of Friction; (4) Compressive Strength; (5) Resistance to Pounding; (6) Toughness.

While there are over one hundred bronze bearing alloys from which to make your selection, we have found through experience that the following will meet practically every application.

Johnson Bronze Alloy No	Average Chemical Composition				
	Copper Cu	Tin Sn	Lead Pb	Zinc Zn	Nickel Ni
19	70.0	11.0	19.0	. . .	. . .
25	75.0	5.0	19.0	. . .	1.0
27	80.0	10.0	10.0	. . .	. . .
29	78.0	7.0	15.0	. . .	. . .
51	87.0	10.0	1.0	2.0	. . .
53	88.0	10.0	. . . .	2.0	. . .
55	86.0	12.0	. . . .	2.0	. . .
66	85.0	5.0	9.0	1.0	. . .
71	85.0	5.0	5.0	5.0	. . .
72	83.0	7.0	7.0	3.0	. . .



Stock Size Bearings

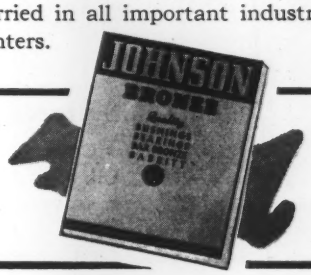
For ordinary service applications and for quick, easy replacement Johnson Bronze maintains a stock bearing service that comprises over 850 individual sizes. This includes inside diameters from $\frac{1}{4}''$ to $4\frac{1}{4}''$; outside diameters run from $\frac{3}{8}''$ to $4\frac{1}{2}''$; lengths are available from $\frac{3}{4}''$ to $8''$. All of these sizes can be quickly altered and any type oil groove, slot or hole can be economically added. Complete stocks are carried in all important industrial centers.

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

Catalogue

Over eighty pages fully illustrated. Lists and describes the most complete stock bearing service in the market. Write for your free copy.



This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze

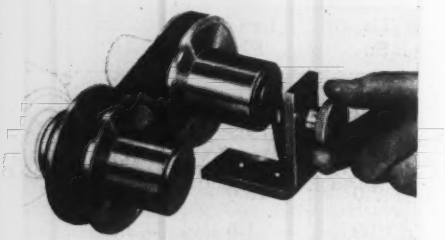
SLEEVE BEARING HEADQUARTERS
525 S. MILL ST. • NEW CASTLE, PENNA.

rapidly. It is available in clear, black or gray high-gloss finish and can be applied by brush or spray. Manufacturer: Dampney Company of America, Hyde Park, Boston 36, Mass.

For additional information circle MD 18 on Page 161

Combination Sheaves

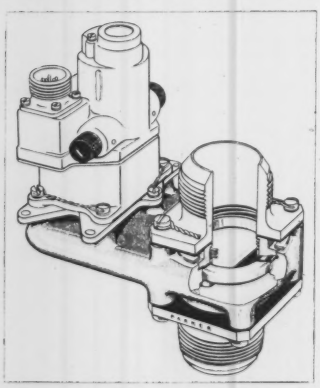
Available in 3, 4, 5, 6, 7 and 8-in. sizes, these combination sheaves can be used to produce speed variations between fixed-center shafts at ratios as high as 7:1. Standard V-belts are used to transmit load which can range from 1/15 to 7½ hp. All except 8-in. size are single-groove design and can be obtained in two types: Spring-loaded and controllable. Built with double grooves, the 8-in. size, for large horsepower



requirements, cannot be combined with smaller single-groove sizes. Spring-loaded variable pitch driving sheave is usually mounted on motor shaft; and controllable pitch sheave, of either same or different diameter, is mounted on driven shaft. Control knob and bracket assembly is secured to machine base and V-belt snapped into place to complete drive. Manufacturer: Speed Selector Inc., 118 Noble Court, Cleveland 13, O.

For additional information circle MD 19 on Page 161

Lightweight Gate Valve



Operating in range of 6 psi vacuum to 75 psi pressure with low pressure drop, this small gate valve can be used to control aircraft fuels, high-temperature air, oil, water-alcohol mixtures, and other fluids. It is produced in 1¼, 1½ and 2-in. sizes with welded aluminum alloy body halves. Floating pressure-balance seal incorporates fuel-resistant synthetic rubber element molded into rigid metal container. Surge pressures as high as 150 psi are accommodated.

Handle travel being only 90 degrees allows manual operation, push-pull remote control or electrical control using actuators which can be furnished in any of several types. Optional thermal relief can be provided to bypass flow in event of pressures rising to 80 psi or higher. Valve opens and closes in 1 second with usual actuator; 2½ to 3-second period is afforded by slow-speed models. Independent mounting plate insures freedom from distortion during mounting, and plate shapes to meet any fastening requirement can be obtained. Manufacturer: Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, O.

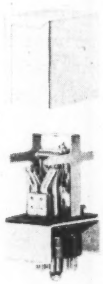
For additional information circle MD 20 on Page 161

Under-Feed Oil

Available in 1, 2 and 4-oz capacities, this under-feed oiler is intended for lubricating bearings and shafts requiring very small amounts of oil. It is mounted at bottom of bearing, one end of solid felt wick being held in contact with shaft by positive spring action. Other end rests at bottom of oil reservoir. Oil is raised by capillary action to tip of wick where it is distributed along shaft. Oiler feeds only when machine is in motion. Metal parts are heavily plated for corrosion resistance, and clear shatterproof plastic bottle keeps oil supply visible. Manufacturer: Trico Fuse Mfg. Co., 2948 N. Fifth St., Milwaukee 12, Wis.

For additional information circle MD 21 on Page 161

Dust-Tight Relay

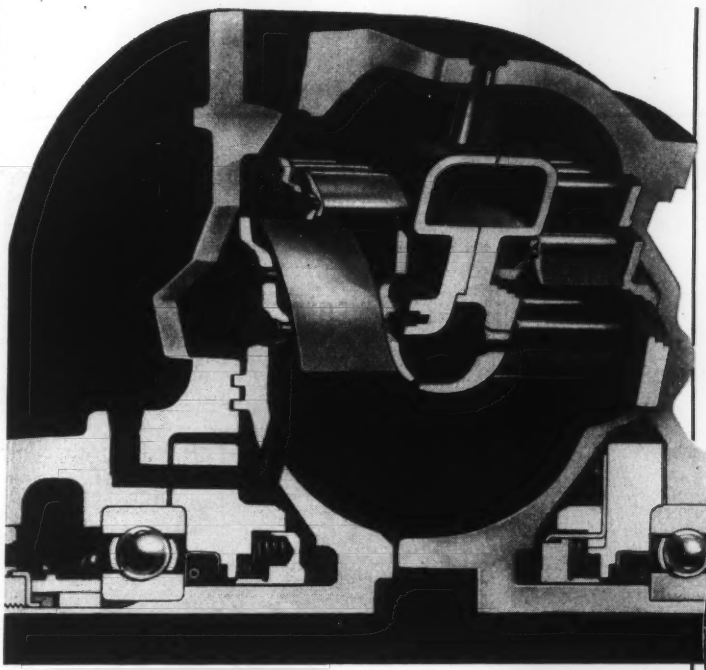


Steel cover and Neoprene gasket closely fitted to terminals form dust-tight plug-in enclosure for type J relay. Installation is facilitated by use of standard radio-type plug. Base is secured to chassis to prevent plug from being jarred or accidentally pulled from socket. Design allows twin contacts to operate independently of each other. At least one contact is practically sure to close, reducing possibility of contact failure. Dust-tight cover is easily removed for inspection. Manufacturer: C. P. Clare & Co., 4719 W. Sunnyside Ave., Chicago 30, Ill.

For additional information circle MD 22 on Page 161

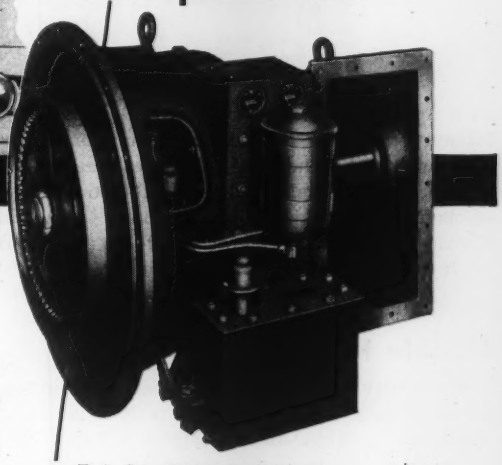
Sintered Metal Bearing

Cavity of uniform size formed in center of Haller Oil Well bearing wall is filled with oil or grease as it is impregnated into sintered metal by static pressure. Since this pocket, as well as the pores in sintered metal body, contains lubricant, bearing can



Sectioned view of Twin Disc Hydraulic Torque Converter

Greatest · Overall TORQUE Multiplication



Twin Disc Hydraulic Torque Converter (Lysholm-Smith Type)

When considering power transmission units for equipment with high torque demands, designers turn naturally to Twin Disc's Lysholm-Smith Hydraulic Torque Converter, because it offers the greatest overall torque multiplication of any unit made today.

The hydraulic circuit of Twin Disc's Converter consists of a centrifugal pump discharging through a *three-stage* turbine, with two reaction stages interposed between the turbine stages. Maximum torque is developed at output shaft stall and is approximately five times engine torque . . . maximum efficiency is attained at an output speed ratio of approximately .5.

To apply a Twin Disc Torque Converter to any engine and machine assembly, it is necessary to select a converter with a proper pump size to absorb engine hp over its complete operating range. The drive ratios in the machine must be properly selected to obtain maximum converter performance throughout the complete range of output shaft operating speed.

The Twin Disc Hydraulic Division offers assistance in solving your power transmission problems. Torque Converter models are currently available with horsepower ratings from 40 to 1000 hp. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

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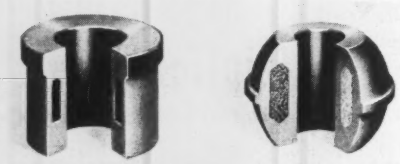
take heavy loads. Because oil is sealed in body of bearing, there is no dripping. It can be hardened and ground and impregnated with oil or grease to suit different conditions.

Bearing is available in three styles. Pocket type which has open cavity is particularly suited for heavy load bearings. Sponge type bearing pocket is filled



with sponge iron to provide capillary action for retaining oil and is recommended for conditions where it is subjected to heat. In thin wall bearings, a group of small holes replaces the pocket so that structure of bearing wall is not weakened. Manufacturer: Michigan Powdered Metal Products Co., Northville, Mich.

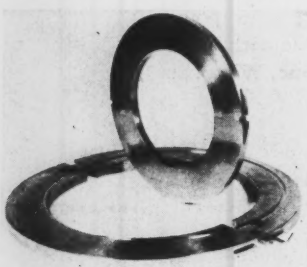
For additional information circle MD 23 on Page 161

Flexible Metallic Conduit

Especially suited for electrical shielding purposes on machines because of its resistance to coolants, moisture, greases and oils, this conduit consists of abrasion-resistant Geon cover applied over highly flexible galvanized convoluted steel tubing. It will not bind or restrict movement when used between moving parts. Liquid-tight steel fittings are usable with both standard and watertight conduit boxes. They are attachable and re-attachable by user or can be permanently attached by manufacturer. Conduit is available in sizes from ⅜ to 2-in. ID, and can be furnished in mill or cut lengths. Manufacturer: Chicago Metal Hose Corp., 1304 S. Third Ave., Maywood, Ill.

For additional information circle MD 24 on Page 161

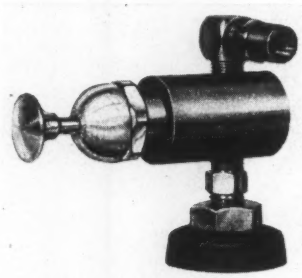
Split Thrust Washer



Made to specification in any practical size, Sabeco split thrust washers can be slipped over shaft and locked with safety key to effect on-the-spot repair without dismantling machine. They can be used on heavy construction machinery, plant machinery, materials moving equipment, oil field equipment, power house and other large electrical installations and large pumping stations. Washers are made of Sabeco bronze which is combination of a high percentage of pure copper, tin and lead with maximum of 0.2 per cent impurities. Manufacturer: Saginaw Bearing Co., 821 S. Water St., Saginaw, Mich.

For additional information circle MD 25 on Page 161

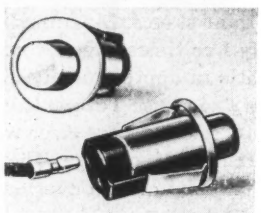
Miniature Lubricator



Having application where closely controlled but infrequent oil feed is required, type LPM miniature one-shot lubricator has efficient filter to prevent foreign particles from being drawn into distribution system. Action of lubricator is initiated by withdrawing pull button, release of which delivers measured quantity of oil to all bearings. It can be mounted in any location and is adaptable to any machine layout. Employed in conjunction with Bijur small-capacity distribution system, lubricator is recommended for use where space limitations are contributing factor and in isolated units involving group of bearings which cannot be connected to main lubricating system of machine. Manufacturer: Bijur Lubricating Corp., 43-01 22nd St., Long Island City 1, N. Y.

For additional information circle MD 26 on Page 161

Momentary-Contact Switch



Capable of being mounted and connected in less than 15 seconds, No. 7712 momentary-contact push-button switch snaps easily into punched hole in metal panel. Expansion spring fingers having ample range to suit panel thicknesses from 0.030 to 0.050-in. grip the panel securely. Electrical connection is made by plugging standard solderless wire terminals into spring contacts recessed in molded phenolic switch body. Body diameter of switch is ⅝-in., flange diameter is 1 in. and overall length is 1 9/16 in. Normally closed single-pole single-throw contacts are opened when button is pushed ⅛-in. Switch is rated at 1 amp, 125 volts ac. Manufacturer: Ark-Les Switch Corp., 51 Water St., Watertown 72, Mass.

For additional information circle MD 27 on Page 161

Oiltight Control Stations

Usable for ac or dc control applications up to 600-v service, type OT Oil-Tite control units and stations employ resilient gasket to seal against entrance of

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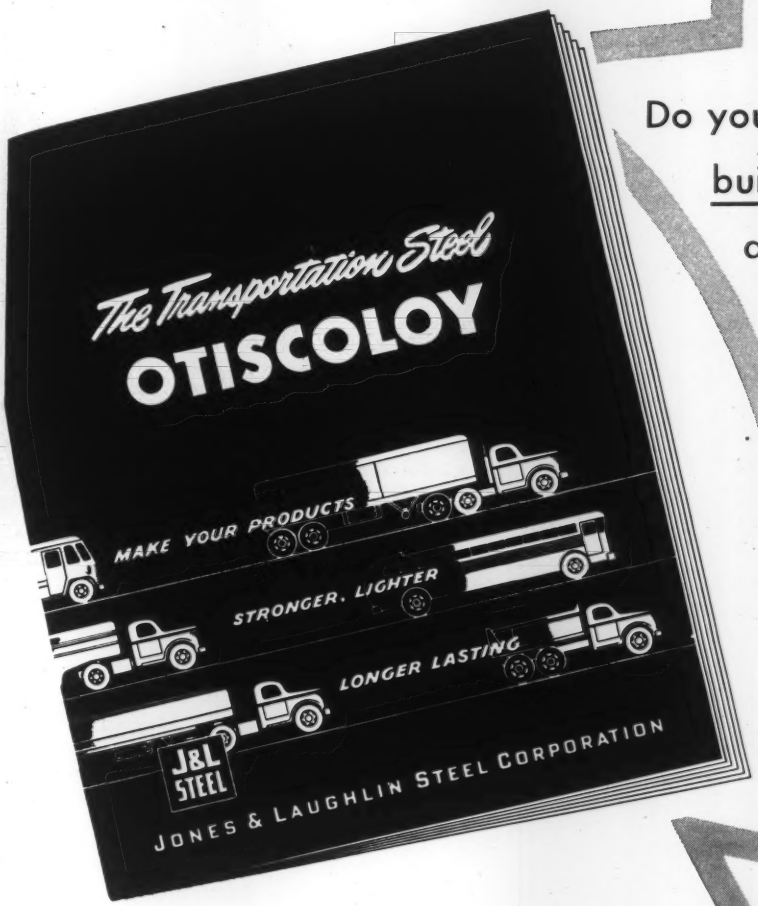

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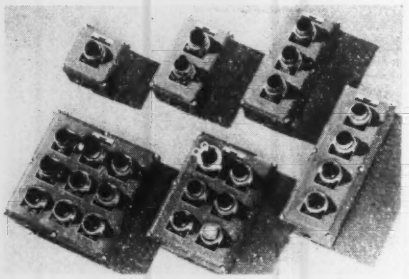
oil, coolant, cutting compound and water. Contact blocks are double-break spring-return type with solid silver contacts. All terminals are easily reversed for front or rear connection. Five contact arrangements are available: Single-pole double-throw, double-pole double-throw, double-pole normally open, double-pole normally closed and tandem assembly. Operating heads are supplied in five types: Standard and mush-



room head pushbuttons, and standard, coin-slot and Select-O-Push selector switches. Indicating lights are obtainable in six standard colors. Operating heads and contact blocks are both interchangeable. Units and nameplates can be rotated to permit surface or cover-mounting in any position. Manufacturer: Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

For additional information circle MD 28 on Page 161

Plastic Insulated Wire

Approved by Underwriters Laboratories for 105 C continuous operation, plastic insulated wire can be used for all hook-up and lead applications. It consists of tinned-copper conductor with insulation of 1/32-in. wall of stabilized vinyl dielectric. Conductor is free-stripping and can be used where soldering operations are employed. Manufacturer: William Brand & Co., 276 Fourth Ave., New York 10, N. Y.

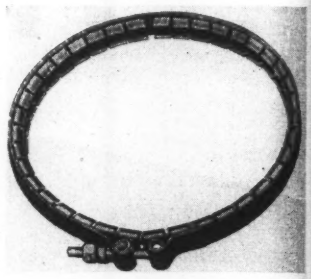
For additional information circle MD 29 on Page 161

D-C Power Supply

Operating from 95 to 135-v 60-cycle single phase line, this Varicell unit delivers stabilized d-c output that is variable from 0 to 30 v. Allowable output current available at any voltage setting is 15 amp. Set value of output voltage does not change, regardless of load or a-c line voltage fluctuations. Stabilization and regulation are within 0.25 per cent for output setting between 6 and 30 v, and rms ripple voltage does not exceed 0.1-v. Manufacturer: Superior Electric Co., Hannon Ave., Bristol, Conn.

For additional information circle MD 30 on Page 161

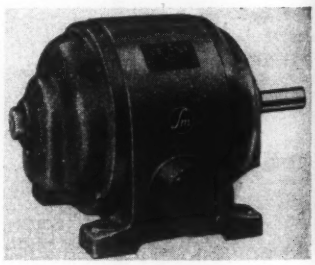
V-Band Coupling



Providing effective seal where rigid high-strength connection is required, line of V-band couplings is adaptable for all types of flanged joints. Suitable flanges to accommodate coupling can be made integral with or added to tubing or ducts to be joined. Rolled sheet metal flanges or machined flanges are equally adaptable, and joints can be made with or without gaskets. Couplings are made in continuous, segmented and ventilated band types. They feature light weight, quick-disconnect provision and dependability over wide range of temperature and pressure. Manufacturer: Marman Products, Inglewood, Calif.

For additional information circle MD 31 on Page 161

Splashproof Motor



Capable of being mounted in any position while maintaining its splashproof features, Klosd motor incorporates labyrinth seals on shaft ends to insure positive protection against entry of liquids into bearing housings. End bells permit free passage of ventilating air through integrally cast baffles that prevent splashing liquids from reaching interior of motor. Air is drawn through rear of motor and exhausted through shaft end, thereby blowing away foreign materials. Features include lubricated-for-life bearings and herringbone rotor. Manufacturer: Sterling Electric Motors, Inc., Telegraph Rd. at Atlantic Blvd., Los Angeles 22, Calif.

For additional information circle MD 32 on Page 161

Vent Type Pipe Plugs

Supplied in pipe sizes from ⅛ to 4 in., breather vent plugs allow closed housings to "breathe" while preventing either entrance of foreign material or gasket blowout from excessive pressure. They are obtainable in cast iron, brass or steel with sintered porous bronze metal as filtering agent. Employing Dry-Seal thread, plugs are interchangeable in any standard pipe threaded hole. Available with countersunk, standard

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This is a strange-looking boot. But it is typical of all Sirvis leather protective boots in that it was designed and manufactured to do a *special* job of protection. Like most of them, besides giving tight sealing over an irregular shape, it allows complete freedom of movement.

When you need positive protection against dust and dirt, together with assured sealing-in of lubricants, call on Chicago Rawhide's Sirvis engineers. They'll be glad to develop the right cover for your control devices, steering and tie rods, drive shafts, hydraulic pistons or other moving parts.

Sirvis Boots

CHICAGO RAWHIDE MANUFACTURING CO.

1304 Elston Avenue SIRVIS DIVISION Chicago 22, Illinois

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For detailed information about Sirvis products, write for the free Chicago Rawhide catalog.

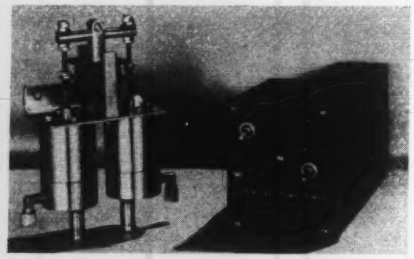
SIRVIS

square or special-type head, plugs can be used in such equipment as gear reduction units, transmissions and housings. Manufacturer: U. S. Plug & Fitting Co., 305 Frederick Bldg., Cleveland 15, O.

For additional information circle MD 33 on Page 161

Metering Pump

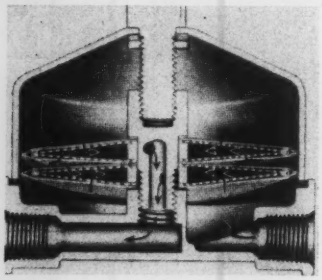
Operated by electronically controlled solenoid which provides variable control of number of strokes per unit time, this pump permits remote control of accurate metering. Additional adjustment of length of stroke is available to maximum output of 0.8-cu in.



per stroke. Precision construction of type 316 stainless steel and direct coupling between solenoid plunger and piston result in efficient and compact unit with low power requirements. Manufacturer: Eastern Industries, Inc., 296 Elm St., New Haven 6, Conn.

For additional information circle MD 34 on Page 161

Air-Fluid Filter

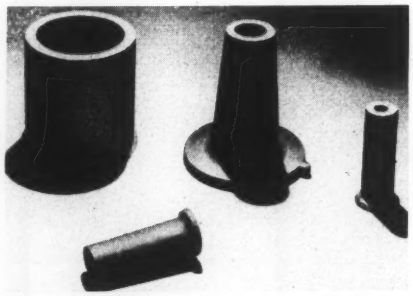


Built in a wide range of sizes, this filter is intended for removing solids down to 1 or 2 microns from liquids, separating water from oils, separating oil from air or water, and purifying gases. Large filtering area within small space is afforded by series of V-shaped horizontal filter disks bolted to housing cover for ease of removal. Each disk consists of two perforated leaves separated at center by perforated flange. Leaves are covered with various filter media, providing wide range of porosity and degree of filtration. Filter housing is pressure-cast aluminum, and all contact parts are rustproofed. Manufacturer: Sparkler Mfg. Co., Mundelein, Ill.

For additional information circle MD 35 on Page 161

Centrifugal Castings

Liners, rings, rolls, sleeves, bushings and other parts requiring extremely dense and compact structure are available as custom centrifugal castings.



Castings can be furnished in all metals and are blanked to customers' specifications. Manufacturer: American Non-Gran Bronze Co., Berwyn, Pa.

For additional information circle MD 36 on Page 161

Snap-Acting Precision Switch

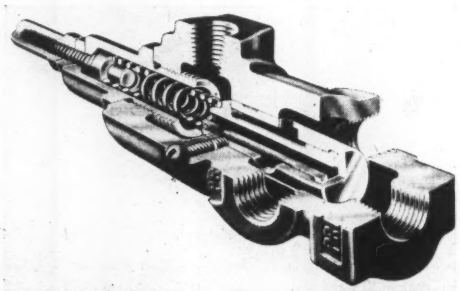
Capable of handling 20 amp at 125 volts, ac, type SXX snap-acting precision switch can be adapted for leaf, leaf-roller, hinged, plunger, push-on, push-off or other actuation by attachment of standard Adaptaplates. Operating force is 9 to 13 oz, release force is 4 oz minimum and movement differential is 0.005-in. maximum. Minimum overtravel is 0.005-in., and maximum pretravel is 0.025-in. Manufacturer: W. L. Maxson Corp., Unimax Switch Div., 460 W. 34th St., New York 1, N. Y.

For additional information circle MD 37 on Page 161

Differential Type Relief Valve

Available in capacities from 5 to 80 gpm, this VR series adjustable differential type relief valve is designed for use in oil hydraulic control systems where pressure ranges from 400 to 1650 psi. Differential piston reduces effective area of main poppet valve without reducing actual flow area. Design allows use of light springs that provide accurate control and long spring life. Manufacturer: Hydraulic Equipment Co., Cleveland 17, O.

For additional information circle MD 38 on Page 161



Correct gasket compression needed for effective sealing

FIG.1

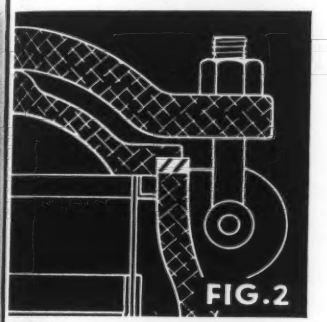


FIG.2

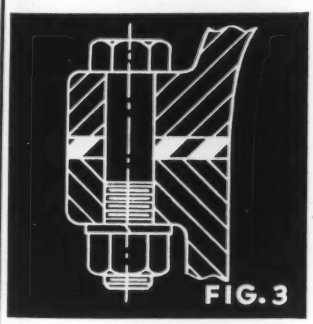


FIG.3

Resilient gaskets seal most effectively when correctly compressed. To insure correct compression, gasket compressibility should correspond to the flange pressure encountered in service. Otherwise, the gasket may be over-compressed and strained by excessive pressure or fail to seal properly because of insufficient pressure.

Correct compression can be achieved on many applications by using gaskets made from an Armstrong's Cork-and-Rubber Composition. Because cork-and-rubber is compounded of highly compressible cork particles and synthetic rubber of various durometer hardnesses, it offers a co-ordinated range of compressibilities capable of sealing effectively under widely varying flange pressures. Hence, choosing a cork-and-rubber material according to the application flange pressure eliminates faulty seals caused by incorrect compression.

Beside offering a wide range of compressibilities, cork-and-rubber provides exceptional resistance to most fluids and solvents. Depending on the substance being sealed, cork-and-rubber compositions made from Buna N, Neoprene, Thiokol, or other synthetic polymers are used.

Typical of the diverse sealing problems solved by cork-and-rubber are the three applications shown here.

In figure 1, a soft Cork-and-Neoprene material compresses 25% under 100 p.s.i. to make the glass cover of a watt-hour meter weather-tight.

A firm Cork-and-Thiokol composition was used to seal an aromatic fuel dispenser in figure 2. Here 500 p.s.i. produced 25% compression.

The 1500 p.s.i. bolt pressure available on the gate valve flange (figure 3) compressed a still firmer Cork-and-Neoprene material the recommended 25%.

Further information on correct gasket compression is available on pages 16 and 19 of the booklet offered below. Write for it today or call your Armstrong representative for further particulars.

Send for this Gasket Handbook

You'll find useful application and specification data in the revised 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date information on straight synthetic rubber, cork-and-synthetic-rubber, and cork composition gasket and sealing materials.

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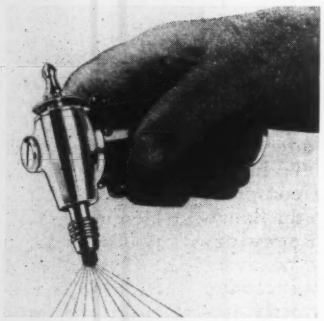
EQUIPMENT

For additional information on this new equipment see Page 161

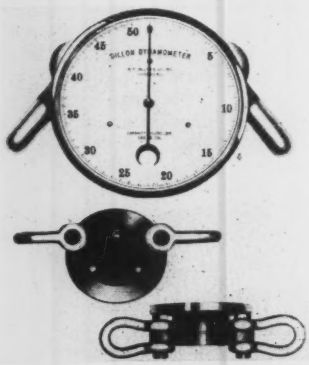
Electric Erasing Tool



Worm gear drive in electric eraser provides 3000-rpm erasing speed, which will not burn or tear paper. Other features are vibrationless motor to permit accuracy in erasing fine detail, weight of only 12 oz, sliding snap type switch for intermittent or continuous operation, quick-action chuck and convenient hanger hook. At opposite end of eraser shaft is burnisher to smooth erased areas for redrawing or reinking. Rotating abrasive disk at base of burnisher sands pencil or compass leads to sharp point. Tool is furnished with three grades of ¼ x ¾-in. eraser tips, six abrasive disks and 6-ft rubber cord and plug. Manufacturer: Dremel Mfg. Co., Racine, Wis.

For additional information circle MD 39 on Page 161

Traction Type Dynamometers



Draw-bar pull, weight of bulky objects, tension in ropes or cables, static loads and other factors can be checked by means of traction type dynamometers which are available in 30,000, 40,000 and 50,000-lb capacities. They have 10-in. dials which facilitate reading and fine increment breakdown. First two models have 200-lb divisions, and illustrated 50,000-lb type has 250-lb divisions. They are all readable to one-half division. All parts are plated or otherwise protected for outdoor use. Manufacturer: W. C. Dillon & Co., 5410 W. Harrison, Chicago 44, Ill.

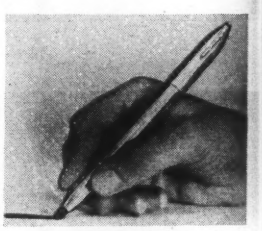
For additional information circle MD 40 on Page 161

Title Block Transfer Forms

Time consumed in printing standard notes, revision boxes, bill of materials forms, title boxes, symbols, standard wiring diagrams, standard parts, etc., can be eliminated by the use of Stanpat transfer forms. The transfer form is applied in the following manner: Wax paper protective sheet is removed from the transfer; form is placed in position on the rear of the tracing; wax paper protective sheet is placed over the form and rubbed gently, the static electricity generated being sufficient to make the form adhere to the tracing; one hour at least is allowed to elapse between application of form and blueprinting because the adhesive used on the form is age hardening. Manufacturer: Stanpat, Whitestone, Long Island, N. Y.

For additional information circle MD 41 on Page 161

Felt-Pointed Indelible Pen



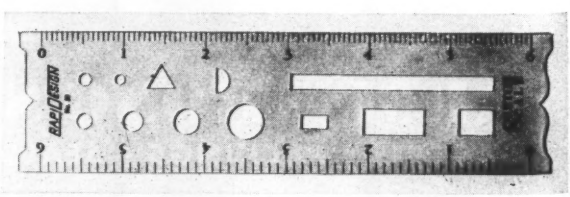
Even such hard-to-mark surfaces as cellophane, wax, glass and metal can be marked by Felt-Point pen. Complete line of pens and various colors of instant drying indelible inks are available that combine all features of crayons, chalk, paint sticks, china pencils, pencils and marking pens. Pen features metal ball-shaped valve, tip that will not fall out or bind, stainless steel lifetime spring, one-piece leakproof barrel and nonslip holding surface. It holds ¼-oz of ink, and plunger hydraulically feeds ink to tip and air to barrel. Manufacturer: Marsh Stencil Machine Co., Felt-Point Pen Div., 709 E. B St., Belleville, Ill.

For additional information circle MD 42 on Page 161

Sketch Scale Template

Scaled in 10ths and 16ths, No. 20 6-inch sketch scale template is transparent pocket rule with cutouts for making field sketches and other drawings. The template is made from 0.030-in. thick matte finish mathematical quality plastic. Manufacturer: Rapidesign, Inc., Box 592, Glendale, Calif.

For additional information circle MD 43 on Page 161



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Everybody using bearings has some idea of what he calls "good performance." It is suggested you match *your* idea with what a SealMaster Bearing Specialist can lay before you on the performance of SealMaster Ball Bearing Units. He will put on your desk a typical pillow-block unit cut-away, as shown above. You will see just *how* the combination of design features, unduplicated in any other bearing, accounts for the many case studies of improved performance.

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4. **No Housing Wear!** Patented locking pin and dimple prevent rotation of outer race in housing, thus eliminating housing wear . . . permit shaft alignment and position unit for relubrication.
5. **Floating Retainer!** Ball retainer is designed to float on ground inner surface of outer race . . . traps lubricant and prevents churning.

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HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

77. Riveted Roller Chains

Chain Belt Co., Baldwin Duckworth Div.—8-page illustrated bulletin No. 50-6 describes Baldwin-Rex BA riveted roller chain assembly. This standard riveted roller chain with special single pin connector link is assembled at 2-ft mark and at end of each basic 5-ft length. It is also supplied in standard short sections of two, six and ten-pitch units.

78. Single-Phase Rectifiers

Accurate Engineering Co.—8-page illustrated bulletin 200 presents information on line of single-phase tube type power rectifiers in direct current output capacities of 115 to 3680 w. Sections are devoted to construction, regulation, circuit employed, efficiency and operation.

79. Fluid Drive

American Blower Corp.—4-page illustrated bulletin No. 7719 lists numerous applications of Gyrol fluid drive in diversified fields to provide smooth transmission of power, stepless variable speed control and torque control. Functions of this hydraulic coupling on motors and engines are listed.

80. Lock Nuts

Palnut Co.—4-page illustrated folder 572 cites case histories of applications of Palnut lock nuts and explains advantages obtained through their use in machines and equipment.

81. Torque Calculator

Stow Mfg. Co.—Pocket-size slide rule is usable for calculating torque loads on flexible shaft equipment. It also indicates size of shaft which performs most efficiently at any given speed within given radius.

82. Prefinished Metals

American Nickeloid Co.—Illustrated folder "How to Put a Crimp in High-Cost Production" shows wide application, rigidity, strength and modern design of prefinished metals. Samples of diagonal, square, diamond and horizontal crimp patterns are included. Each is available in variety of finishes and base metals.

83. Oil-Hydraulic Cylinders

Vickers Inc.—28-page illustrated bulletin No. 49-55 presents complete data on line of oil-hydraulic cylinders which are available for foot, flange, trunnion, centerline, reverse flange or clevis mounting. Head end, rod end or both can be cushioned; and various mountings can be combined for mounting auxiliary equipment or for additional support.

84. Motor Control

Allen-Bradley Co. — 76-page illustrated "Handy" catalog, fourth edition, lists various accessories and components for motor control including manual and magnetic across-the-line starting switches, reduced voltage starters, control relays, synchronous starters, high voltage starters and similar equipment for direct current motor control.

85. Heating Elements

Cutler-Hammer, Inc. — 6-page illustrated folder HE-23 describes Pyroflex heating elements and thermostats for electric water heaters. Elements feature pressure-type wire connectors, flat Bakelite terminal blocks, Heli-Arc welded terminal plates and watertight flange. Thermostats are clamp-on type and provide maximum safety through vapor power operation.

86. Rotary Positive Blowers

Roots-Connersville Blower Corp. — 20-page illustrated bulletin No. 22-23-B-13 discusses rotary positive blowers available in wide range of sizes from 5 to 50,000 cfm for pressures up to 15 psig.

87. Sprockets and Chain

Cullman Wheel Co.—52-page illustrated catalog No. 50 is guide to all types of sprockets and chain for power transmission. Specification tables, design drawings and illustrations of use are included.

88. Air-Operated Controllers

Bristol Co.—32-page illustrated bulletin No. A120 gives information on series 500 air-operated controllers for automatically controlling temperature, pressure, flow, liquid level, humidity and pH value. Complete data are presented on proportional, on-off, reset, derivative and reset plus derivative models.

89. Articulated Flexible Couplings

Estey Co.—Illustrated leaflet "Estey Articulated Flexible Couplings" describes units having synthetic rubber spider molded into steel retaining band to provide high degree of resilience and flexibility with great strength and adaptability.

90. Custom-Cut Gears

Perkins Machine & Gear Co.—4-page illustrated bulletin explains engineering service for manufacturing precision metallic and non-metallic helical, bevel, spiral-bevel, worm, spiral, spur and ground thread worm gears for specific applications.

91. Special Alloy Steel

Jones & Laughlin Steel Corp.—36-page illustrated brochure "For Longer Wear, Less Repair" discusses Jalloy special alloy steel which is capable of being heat-treated to excellent physical properties. Case histories of applications in mining, quarrying and earth-moving fields are presented.

92. Hydraulics

Baldwin Locomotive Works—36-page illustrated bulletin No. 300 presents capacities of hydraulic rams, displacements of single-acting plungers, steel pipe tables including water flow rates and friction losses of fittings, and bolt strength and size data. It also tells how to determine when to use accumulators, pumps, intensifiers and shock valves.

93. Steel Wire Products

Colorado Fuel & Iron Corp.—36-page illustrated catalog entitled "Principal Products of CF&I" lists various steel and wire products. Typical items include semifinished and hot-rolled steel, rails and accessories, wire and wire specialties, wire rope, welded wire fabric, netting, fencing, springs, automotive products and conveyor belts.

94. Retractile Cords

Koiled Kords, Inc.—4-page illustrated bulletin KKG depicts retractile neoprene electric cords that are permanently coiled into spring-like shape to provide for extension and retraction. They are recommended for use on industrial, communications and entertainment equipment.

95. Industrial Bearings

Johnson Bronze Co.—84-page illustrated catalog No. 500 presents information on general purpose bearings, oil grooving, universal cored bars, solid and hexagon bars, babbitts, graphite bearings, and electric motor bearings.

96. Rings & Assemblies

Dresser Industries, Inc., Dresser Mfg. Div.—Illustrated folder "If You Can See Your Product as Rings . . ." explains processes involved in fabrication of stainless and other steel rings, motor frame assemblies, and wide variety of other ring shapes and weldments.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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97. Right Angle Gear Unit

Airborne Accessories Corp. — 4-page illustrated catalog is devoted to R-300 two-way and R-310 three-way standardized right-angle gear units that have been redesigned for universal mounting. Units now include rectangular four-hole mounting flange with internal pilot on both ends of housing in addition to three-hole mounting originally employed. Units are rated at 250 lb-in. static torque capacity or to transmit 1/3-hp at 1800 rpm.

98. Slide Switches

Stackpole Carbon Co.—1-page illustrated catalog sheet describes SS-26 single-pole single-throw and SS-26-1 single pole double-throw slide switches rated 1-amp 125-v dc and 3-amp 125-v ac. Both are Underwriters' Laboratories approved and are recommended for appliances, toys and electrical equipment requiring 3-amp switch contact carrying capacity.

99. High Pressure Hydraulics

Hannifin Corp.—32-page illustrated bulletin No. 150 discusses use of hydraulic pressures up to 5000 psi for wide variety of high speed production operations including "silent squeeze" riveting, punching, pressing, multiple riveting and multiple punching. Detailed description and schematic diagrams are presented on operation of Hy-Power hydraulic pressure generator and cylinders.

100. Synchronous Motors

Allis-Chalmers Mfg. Co.—16-page illustrated bulletin No. 05B6112A discusses operating advantages and construction features of bracket bearing synchronous motors in sizes from 30 to 1000 hp. Motors with special features, types for belted service, vertical synchronous motors which are built in all sizes for pump drives and other applications, exciters and starters are covered also.

101. Speed Reducers

De Laval Steam Turbine Co.—28-page illustrated bulletin G-WB contains complete description of standard IMO horizontal worm gear speed reducers. Shown are all available types along with standard specifications. Other data include horsepower rating tables, overhung load ratings, dimension tables and information on how to select worm gears.

102. Socket Screws

Parker-Kalon Corp. — 16-page illustrated Form No. 490 contains engineering data on various types of Parker-Kalon high tensile alloy and stainless steel socket screws. Standard sizes are listed for all types. Also described are stripper bolts, pipe plugs and hexagon keys.

103. Gas Service Stops

Hays Mfg. Co.—16-page illustrated folder No. 120 presents line of Securo and Key-Lok iron body tamperproof gas stops and standard iron body heavy pattern gas stops for low, medium and high working pressures. Applications include meter settings, service lines and general industrial use.

104. Shipping Containers

Steel Drum Packaging & Acc. Inc.—4-page illustrated folder entitled "Sealed in Steel" depicts reusable steel shipping and storage containers designed to keep product damage at minimum. Containers range in size from 4 to 55-gal capacity and can be used for shipping products ranging from delicate instruments to heavy-duty parts.

105. Combustion Safeguard

Wheelco Instruments Co.—4-page illustrated bulletin F2-1 is descriptive of model 1300 Flame-otrol combustion safeguard for oil and gas-fired furnaces, ovens, boilers, kilns and other heating equipment.

106. Heat Treating Chart

Tempil Corp.—Plastic-laminated wall chart entitled "Basic Guide to Ferrous Metallurgy" measures 16¼ x 21 in. and shows working characteristics of steels in temperatures from —300 to 2900° F. Temperature zones for hot-working, annealing, normalizing, stress relieving, carburizing and preheating of welded products are clearly defined.

107. Small Ball Bearings

New Hampshire Ball Bearings, Inc.—12-page illustrated bulletin No. 50 is descriptive of line of standard and special fully-ground ball bearings. Available designs include Conrad, full race and extra light radial; angular contact; self-aligning; and pivot in outside diameters of ⅛ to ⅝-in. of alloy steel, stainless steel and nonmagnetic beryllium copper.

108. Shaft Seals

Syntron Co.—4-page illustrated form 2-46 describes Anti-Friction mechanical shaft seals for eliminating leakage of gases and liquids around rotating shafts of compressors, pumps, turbines, engines, machines and propeller shafts. Applications are shown, components are discussed and installation procedure is outlined.

109. Synchronous Generators

General Electric Co.—8-page illustrated bulletin GEA-5415 deals with Tri-Clad high speed synchronous generators for standby, portable and prime source power in wide-spread fields of application. Construction features, mechanical modifications and performance data are presented also.

110. Precision Castings

Michigan Steel Casting Co.—20-page booklet "Misco Carbon and Stainless Steel Precision Castings" contains technical information on production of hard-to-machine parts in highly alloyed stainless as well as in carbon and low alloy steels.

111. Fasteners

Lamson & Sessions Co.—12-page illustrated catalog "Fasteners for Machines that Move Mountains" contains brief descriptions of cap screws, reusable locknuts, plow bolts, engine nuts, tractor bolts, machine and carriage bolts, semifinished nuts, cotter pins, wire rope clips, pipe plugs, set screws, U-bolts, cylinder head and manifold studs, self-tapping screws, and plain and lock washers.

112. Colored Rubber

Stalwart Rubber Co.—4-page illustrated folder "Your Color in Rubber" reveals company's ability to duplicate any color in rubber products, regardless of shade or tone. Colored rubber parts can be furnished having resistance to weathering, petroleum, acids, alkalies, abrasion and high and low temperatures.

113. Bronze Bar Stock

American Brake Shoe Co., National Bearing Div.—6-page illustrated bulletin "N-B-M Tiger Bronze" reviews line of cored and solid bronze bars in all popular sizes, both rough and machined. Sizes, weights, physical properties and uses of this shock-resistant antifrictional material are included.

114. Fastening Devices

Pheoll Mfg. Co.—28-page illustrated Catalog No. 80-A describes Sems assembled screws with free-rotating washers. These units afford ease and speed of assembly. Products described include screws in round, pan, truss, fillister, flat and oval head styles in both slotted and Phillips types. Hexagon head fasteners are available in plain, indented and slotted head types.

115. Photo-Copying Machine

Haloid Co.—8-page illustrated bulletin FF-1 covers applications and operation of new model C Foto-Flo photo-copying machine. It will reproduce anything written, printed, drawn, typed or photographed at speeds of three 18 x 24-in. sheets per minute. Prints can be actual size, enlarged or reduced.

116. Packing Expander

HPL Mfg. Co.—1-page data sheet on U-Expander explains construction and application of this strip type, metal spring expander designed to fit many diameters and heights of packings on hydraulic equipment.

117. Investment Casting Alloys

Precision Metalsmiths, Inc. — 3-sheet data file is compilation of chemical compositions, mechanical and physical properties, heat treatment and other information on more than 80 alloys which can be supplied in form of precision investment castings.

118. Ball Bearings

Nice Ball Bearing Co.—Illustrated catalog No. 140 lists radial, thrust and combined radial-thrust ball bearings ranging from close tolerance precision units to inexpensive pressed steel bearings of unground type. Also discussed are composition sealed bearing design and other products including bearing sheaves, rollers, wheels and casters.

119. Self-Lubricating Packings

Greene, Tweed & Co.—4-page illustrated bulletin LP-10 covers principles of self-lubricating packing design, structure and performance as well as analysis of each packing type from standpoint of application for specific services.

120. Self-Aligning Bearings

Halfco Bearing Div., Marsam Enterprises, Inc.—4-page illustrated folder tabulates dimensions and application data on Halfco two-piece integrally-formed self-aligning bearings. Spherical-contact bearings are described also.

M. D. Numbers					
1	21	41	61	81	101
2	22	42	62	82	102
3	23	43	63	83	103
4	24	44	64	84	104
5	25	45	65	85	105
6	26	46	66	86	106
7	27	47	67	87	107
8	28	48	68	88	108
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14	34	54	74	94	114
15	35	55	75	95	115
16	36	56	76	96	116
17	37	57	77	97	117
18	38	58	78	98	118
19	39	59	79	99	119
20	40	60	80	100	120

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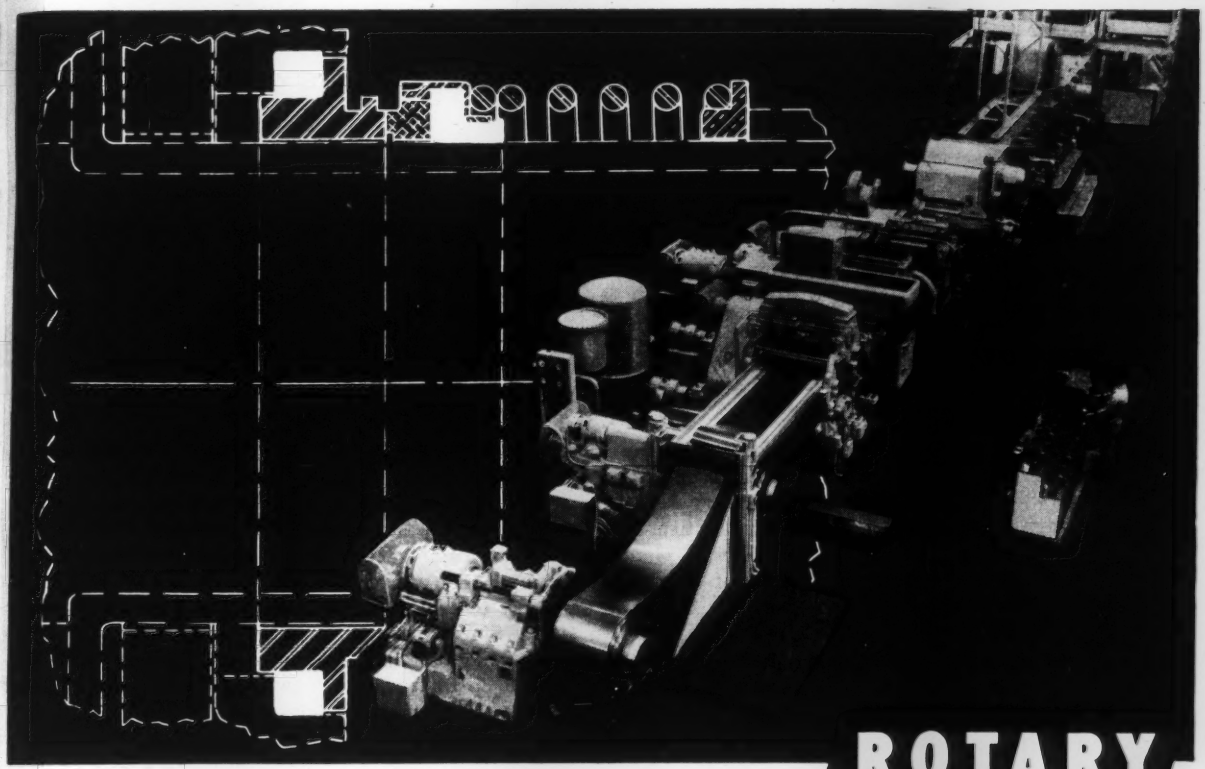
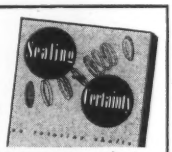


for *Certainty* in *Shaft Sealing* on this Wean electrolytic tinning line—

ROTARY SEALS

THE ROTARY SEAL PRINCIPLE



is the original approach to a practical solution of a universally troublesome problem. Our booklet "SEALING WITH CERTAINTY" explains and illustrates the principle. We're glad to send it to you without obligation.

You can't get efficient electrolytic tinning on a stop-and-go basis. The expertly engineered line developed by Wean Engineering Co., Cleveland, is built to run fast, continuously, free of trouble. And at the heart of this complex equipment, you'll find Rotary Seals providing the *certainty* of Shaft Sealing which can be depended upon to prevent interruption of production from this source.

The particular Seals used in Wean equipment are special adaptations of the basic Rotary Seal principle, developed to fit the specific requirements. Manufacturers in many lines have found that Rotary Seal engineers come up with the right answers for the toughest sealing problems. We can do the same for *you*—for best results and greatest economy, call us in on the job early. And inquire about the new *Type N* Seal, developed especially to speed up production on assembly lines.

THE mechanical seals for ROTARY SEAL COMPANY rotating shafts

2022 NORTH LARRABEE STREET
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MEN OF MACHINES

H. Walter Regensburger

Link-Belt Co. announces the appointment of **H. Walter Regensburger** as chief engineer of its general engineering department, Chicago. Mr. Regensburger succeeds **Harry L. Strube** who has retired. A mechanical engineering graduate of Armour Institute of Technology, Mr. Regensburger joined Link-Belt in 1926 at the Caldwell plant, Chicago, and has served in the estimate-engineering departments of the Chicago plants. He was chief engineer at the Atlanta plant from 1936 to 1944 and assistant to the vice president in charge of engineering in Chicago from 1944 to 1947. Since then he has been located at the Pershing Road plant, first as divisional engineer and then as assistant chief engineer. Assisting Mr. Regensburger will be **Charles M. Young, Jr.**, chief developmental engineer, and **Harold F. Watson**, chief standards engineer.

Stephen A. Sloan

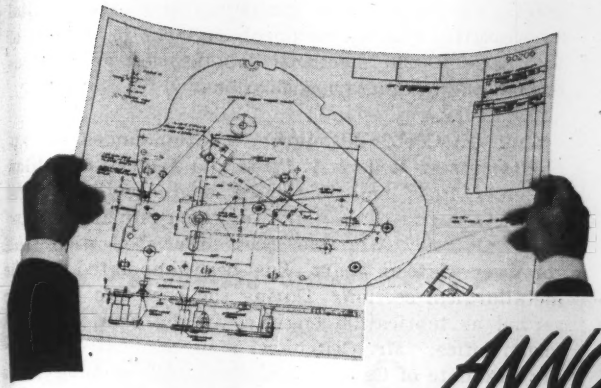
Announcement has been made of the appointment of **Stephen A. Sloan** as manager of research and development, Peabody Engineering Corp., New York. In his new capacity Mr. Sloan will be charged with the responsibility of extending the present line of Peabody equipment as well as developing new products. Prior to his association with Peabody he spent 15 years in boiler, turbine and general combustion fields.

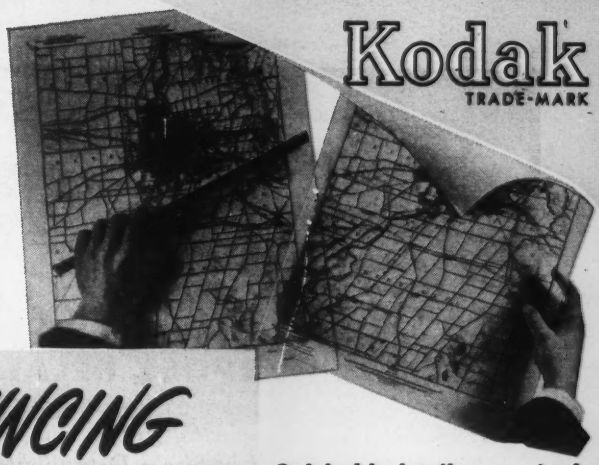
Donald D. Stone

Donald D. Stone has been named automotive power plant engineer at Willys-Overland Motors, Inc., Toledo. Joining the company in 1939 as a research engineer, he was later appointed director of research, a post he held until 1947 when he was assigned the duties of equipment engineer. In the research department of Willys-Overland, Mr. Stone aided in the development of the 4-cylinder Jeep Go-Devil engine. He also participated in the development of the wartime Jeep which later evolved into the civilian Jeep. The early development of the Willys 6-cylinder engine was undertaken while he was research director, as well as the planning of the Jeep underwater conversion unit. Prior to joining Willys-Overland Mr. Stone was affiliated with the Buick Division of the General Motors Corp. where he was active in creation of the straight eight engine, a forerunner of the present Buick motor.

♦

Appointment of **Clarence H. Endress** as chief engineer of Willard Storage Battery Co., Cleveland has been announced. He joined the Willard organization in 1920 as a laboratory assistant. During his career he has served as process en-





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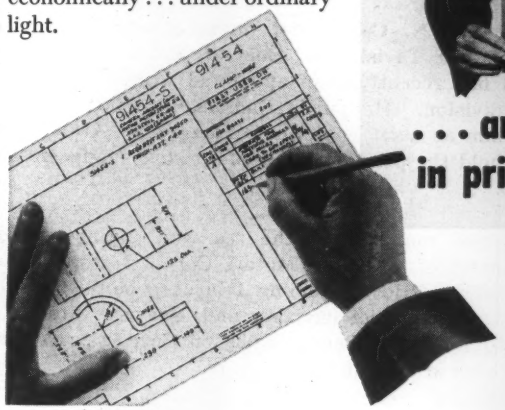

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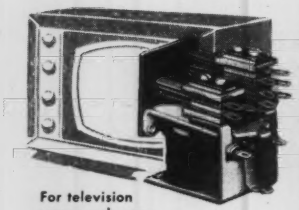

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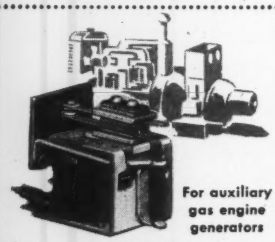

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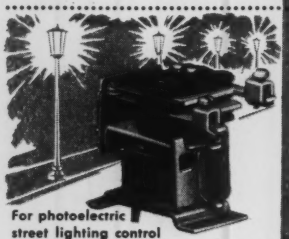

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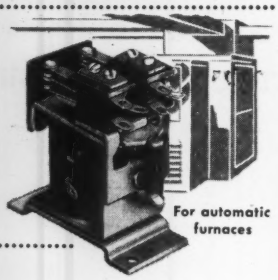

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gineer, as head of the production and experimental laboratories, and as electrical engineer in charge of the battery and electrical laboratories as well as branch plant process specifications.

Gulf Oil Corp., Pittsburgh, has announced the appointments of **Robert A. Fitch** and **John J. Critchlow** as chief fuels and lubricants engineers, industrial products engineering. Mr. Fitch, a graduate of Purdue University, who has been associated with Gulf for over sixteen years, has been appointed to the metallurgical section. During the past two years he served as lubrication engineer in the New York division office. Mr. Critchlow, a mechanical engineering graduate of Carnegie Institute of Technology, has been assigned to the rolling mill section. Prior to joining Gulf in 1947 as a lubrication engineer he had been associated with Mesta Machine Co. for thirteen years as a rolling mill design engineer.

E. K. Brown, formerly chief engineer of the Torrington Needle Bearings Division, has been appointed director of research for the Torrington Co., Torrington, Conn. **B. T. Virtue** will succeed Mr. Brown as chief engineer of the Needle Bearings Division.

R. B. Haynes has recently been appointed to the newly created position of vice president in charge of manufacturing of the various divisions of Dana Corp., Toledo. He joined the Spicer Mfg. Corp., now a division of Dana Corp., in 1935 and was formerly works manager of the Toledo plant.

Edward N. Cole, chief engineer of the Cadillac Motor Car Division of General Motors Corp. since 1946 has recently been appointed works manager of the division. He joined Cadillac in 1930. Succeeding him as chief engineer is **Charles F. Arnold,** who has held the position of assistant chief engineer since 1946.

Named manager of the research engineering department of Dearborn Motors Corp., Detroit, is **Ray J. Miller.** Prior to joining Dearborn Motors in 1949 he served as chief engineer and assistant director of research for the Bendix Aviation Corp. research laboratories in Detroit for six years.

Announcement of the appointment of **Edwin M. Fisk** as general manager and vice president in charge of engineering at the American Fisk Engine Co. Inc., Dallas, Tex., has been made. He was formerly chief engineer with the Reed Mfg. Co.

M. A. Rhoads is now chief engineer in the hydraulic division of the Auto Specialties Mfg. Co., St. Joseph, Mich. He was formerly chief engineer with the Columbian Vise & Mfg. Co., Cleveland.

William P. Mohan has joined the Aviation Gas Turbine Division of the Westinghouse Electric Corp., Lester, Pa., as a design engineer. Previously he was supervisor of the Experimental Test Division of Wright Aeronautical Corp., Wood-Ridge, N. J.

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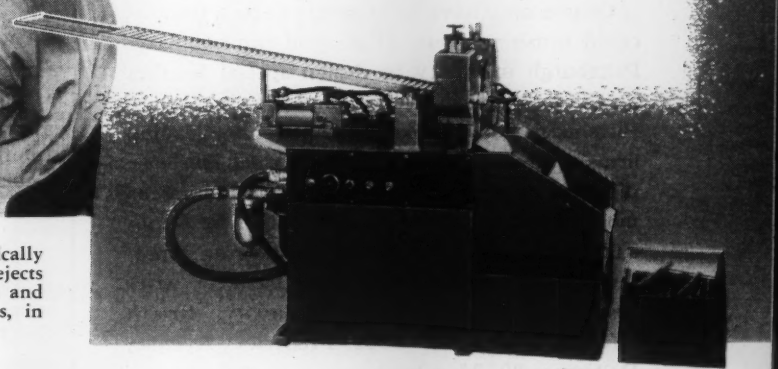

This machine gages and sorts straight sleeves—measuring for length as well as diameter at both ends. The sleeves are segregated into four categories. **1.** *Oversize and undersize in length regardless of diameter.* **2.** *Small in diameter at either or both ends.* **3.** *Large in diameter at either or both ends.* **4.** *Good sleeves within tolerance.*

The machine has a production rate of approximately 3000 per hour. The capacity is adjustable for different lengths and diameters. It is loaded manually with automatic disposal.

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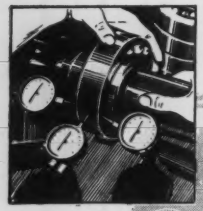

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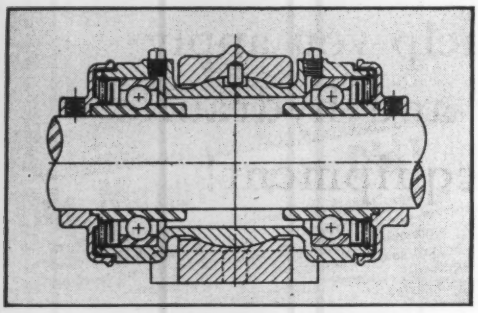

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Arthur, Ont. The company also purchased Freyn Engineering Co., Chicago, Ill., and its wholly-owned subsidiary, Open Hearth Combustion Co., as announced in the July, 1949 issue of MACHINE DESIGN.

♦

The **Wheelco Instruments Co.**, Chicago, Ill., manufacturer of electronic controllers, recorders and combustion safeguards, have licensed a French instrument manufacturer, La Pyrometrie Industrielle, Paris, and its subsidiary to manufacture the Wheelco Capacitrol, electronic controller, and the Flame-otrol, combustion safeguard.

♦

Formerly occupying two plants in the Los Angeles area, **Preco Inc.** has consolidated its operations in a new factory and office building at 6300 East Slauson Ave., Los Angeles, Calif. Preco manufactures heaters, air circulating fans and precooling equipment for refrigerator cars, small hydraulic presses, and farm and industrial implements.

♦

Williams & Hussey Machine Co. Wilton, N. H., manufacturer of special machinery and "Star" gages, has transferred the manufacturing operations of the **O. K. Tool Co.** from Shelton, Conn., to Wilton. Williams & Hussey acquired the tool company, manufacturer of single point and inserted blade type milling cutters, in 1949, as announced in the December issue of MACHINE DESIGN. Although operations have been transferred, O. K. Tool Co. will retain its identity and operate as a division of Williams & Hussey.

♦

The business of **Jackson Electro Corp.**, 124 Bleeker St., New York, N. Y., manufacturer of soldering irons, has been acquired by **Vulcan Electric Co.**, Danvers, Mass., manufacturer of electric soldering tools and heating units. Manufacturing operations will be transferred to the Vulcan plant in Danvers, but in the field the Jackson name will be retained.

♦

Purchase of a new and larger plant at Hilton and Holly Streets, Easton, Pa., has been announced by **Stover Lock Nut & Machinery Corp.**, manufacturer of the patented Stover Lock Nut and other types of special and common nuts. All operations are now being conducted at the new plant.

♦

The **Roto-Finish Company** has transferred its operations from Sturgis, Mich., to its new factory at Kalamazoo, Mich.

♦

National Lead Co. and **Allegheny Ludlum Steel Corp.** have announced the formation of Titanium Metals Corp. of America, a new jointly owned organization which will market and distribute titanium metal, its alloys and various related products. The new company will make its headquarters in New York, N. Y.

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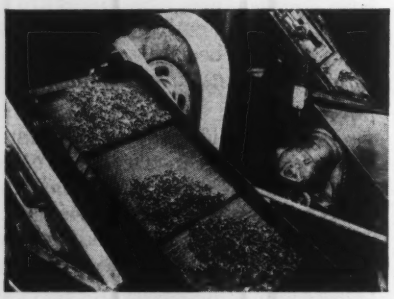

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Tool Engineers Handbook

Prepared by the American Society of Tool Engineers; Editor-in-Chief, Frank W. Wilson; published by McGraw-Hill Book Co., New York; 2070 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$15.00 postpaid.*

This extensive compilation should prove a valuable, permanent source of working knowledge and pertinent design data for the engineer engaged in manufacturing.

Material covered in the volume can be divided into the following major subjects: Production planning and control; materials and machinability; metal processing methods; design of fixtures, dies and tools; design of gears, bearings, springs, and other elements; machine tool control and feeding devices; limited-production tooling; mathematics and physics related to the above subjects.

Each of these general topics is subdivided, and the specialized divisions are treated in detail by an authority in the field. As a matter of illustration, the subject of production planning and control is divided as follows: Product analysis, cost estimating, time study, job planning, routing, scheduling, dispatching, materials handling, small tools planning, reclamation and salvaging, and other related topics. The discussions are sufficiently supported by charts, reference tables, graphs and illustrations to result in thorough understanding of any phase studied.

□ □ □

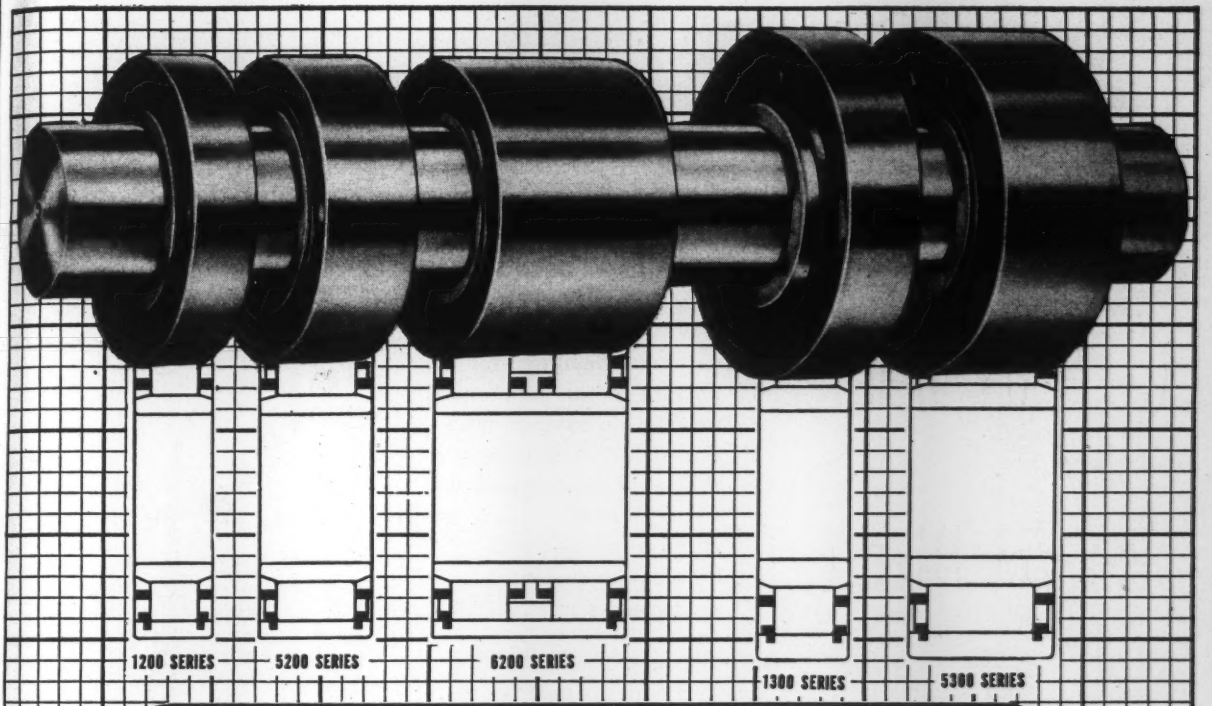
Materials Engineering of Metal Products

By Norman E. Woldman, consulting metallurgical engineer and faculty member, Cooper Union School of Engineering and Stevens Institute of Technology Graduate School; published by Reinhold Publishing Corp., New York; 583 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$10.00 postpaid.*

This volume, written as a companion to *Metal Process Engineering* which described the various metallurgical and mechanical processes for fabricating metal parts, assists the designer and materials engineer in selecting the type of metal or alloy best able to meet a given set of service conditions.

The contents of the book are divided into five sections: Materials for Lightweight Construction—aluminum alloys, magnesium alloys, high-strength, low-alloy steels, stainless steels; Materials for Mechanical Products—gear, spring, bearing, and thread-

(*Concluded on Page* 175)



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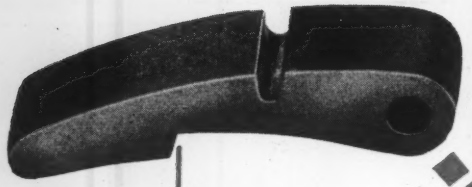
HYATT ROLLER BEARINGS



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(*Concluded from Page* 175)

ed fastener materials; Materials for Electrical Industry—magnetic, electrical contact and thermostatic materials and electrical resistance alloys; Materials for Special and Severe Service—corrosion-resistant and high-temperature materials; Testing of Materials—mechanical and nondestructive testing.

Clearly and simply the text devotes full discussions to the advantages and disadvantages of all various types of metals and alloys in specific service applications. Accompanying the text are numerous tables of data on physical properties and performance statistics together with illustrations, especially pertinent being those which are relative to the various types of metal failures.

Manufacturer and Association Publications

Review of Current Research-1949: Published by the Engineering College Research Council of the American Society for Engineering Education, this 186-page book lists more than 4000 current research projects being conducted in 82 colleges and universities. Entries in the book describe the administrative policies for conducting engineering research and list the responsible personnel, research, expenditures, short courses and conferences of special interest, and the titles of all engineering research studies currently active. Use of the volume is facilitated by a breakdown of research projects according to departments involved and by a complete index to research project subjects. Copies of the book may be obtained by writing to F. M. Dawson, College of Engineering, State University of Iowa, Iowa City, Iowa. Price per copy is $1.75.

Steels for Elevated Temperature Service: Information presented in the 8½ by 11-in., 87-page booklet can be broken down into the following major categories: General principles of elevated temperature behavior of ferrous materials and the factors that influence this behavior; tabular and graphical data presenting specific mechanical properties of twenty-one different steels covering a variety of chemical compositions; major elevated temperature testing facilities embodied in specially designed equipment of U. S. Steel laboratories; and a comprehensive bibliography of U. S. S. technical publications pertaining to the properties and use of steel at elevated temperatures. The book may be obtained by addressing company-letterhead request to Carnegie-Illinois Steel Corp., Pittsburgh 30, Pa.

Engineering for Production: A 180-page manual compiled by Walter Ernst and a staff of consulting engineers of Commonwealth Engineering Co., containing charts, tables and general data on production methods and standards. Manuals may be obtained from Research Press Inc., Dayton, O. Price, $10.00 per copy.

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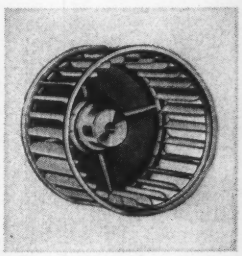
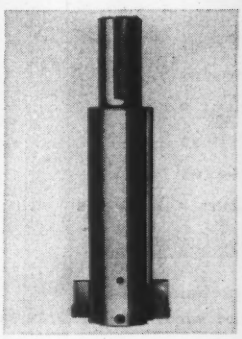


1 Make it tight against vibration

An air impeller, for example. The fasteners are under *continual* vibration. A famous manufacturer of air-moving equipment (name on request) uses Bristol's Multiple-Spline Socket Set Screws because the multiple-spline socket permits tightening much further than possible with any other screw.



2 Make it easy to adjust

Boring bars, for example, where the cutting blade is adjusted by turning a screw. A well-known tool manufacturer (name on request) uses Bristol's Multiple-Spline Socket Set Screws because the tight set is easily broken by a flick of the wrench—with no spoiled screws.

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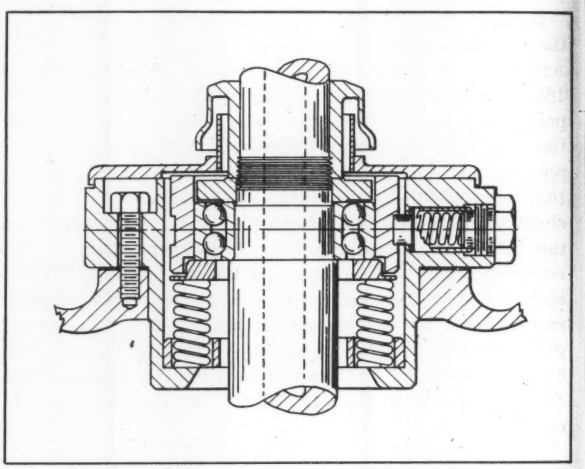
NOTEWORTHY PATENTS

BEARING VIBRATION MOUNTING to accommodate both radial and axial movement of a rotating shaft is described in patent 2,487,343 assigned to The DeLaval Separator Co. by Frank S. Kopf. The outer race of a ball bearing is mounted with a sliding fit in a ring or sleeve centered around the shaft by compression springs. A thrust plate or disk supports the outer bearing race in the axial direction and is



also spring mounted. The bearing was originally designed for centrifuge spindles, where a slight unbalance of the bowl sets up high radial bearing loads and axial unbalance can be caused by the downward thrust of a plunger opening a discharge valve on the periphery of the bowl.

SLIDING PISTONS, similar in action to those in a swash-plate type pump, are used to transmit torque in the universal joint disclosed in patent 2,485,893. Each of the two rotating shafts terminates in a cylindrical head or barrel section, the two heads being held together by a ball-and-socket joint. A series of sliding pistons are provided close to the outer periphery of these head sections. On each shaft, a collar resembling a swash plate is free to assume any angle of tilt and bears against the outer ends of the pistons. The inner ends are recessed to carry a ball between each pair of pistons. Rotation of the drive shaft causes the tilted collar to move the pistons in the drive head, driving the pistons in the other head and causing the driven shaft to rotate.

Since the collars are tilted the same amount on

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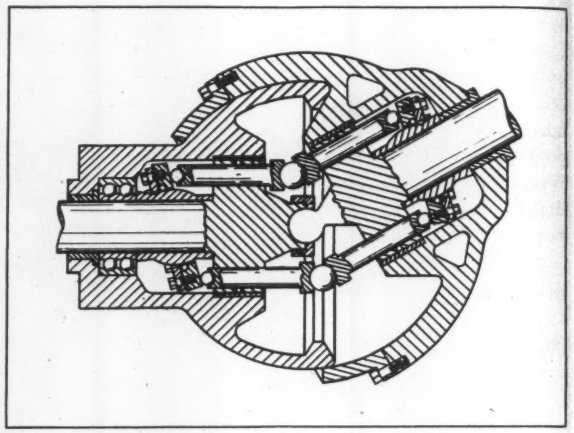
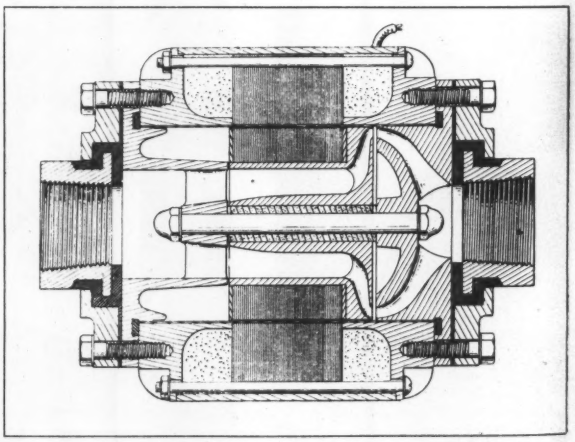
each shaft, but displaced 180 degrees angularly, contact is maintained at all times between collars, pistons and piston balls. The ball-and-socket construction of the housing permits free operation of the uni-



versal joint at any angle up to maximum and in any direction. The unit, patented by Alwin Kost, will operate at high speeds since axial piston forces in one direction are balanced by equal piston forces in the other direction.

COMBINED pump and motor described in patent 2,485,408 is designed to be directly connected into a pipe line or similar installation. Stator coils are protected from the fluid being pumped by a shrink-fitted, nonmagnetic sleeve between stator and rotor and are surrounded with insulation to reduce motor noise. An



impeller is press fitted inside the tubular rotor which employs a carbon sleeve type bearing containing slots for the introduction of a high presure lubricant. Intake and discharge piping is insulated from motor noise and vibration by molded sealing gaskets. Albert R. Pezzillo has assigned the patent to Republic Industries Inc.

How to be right in the center of things

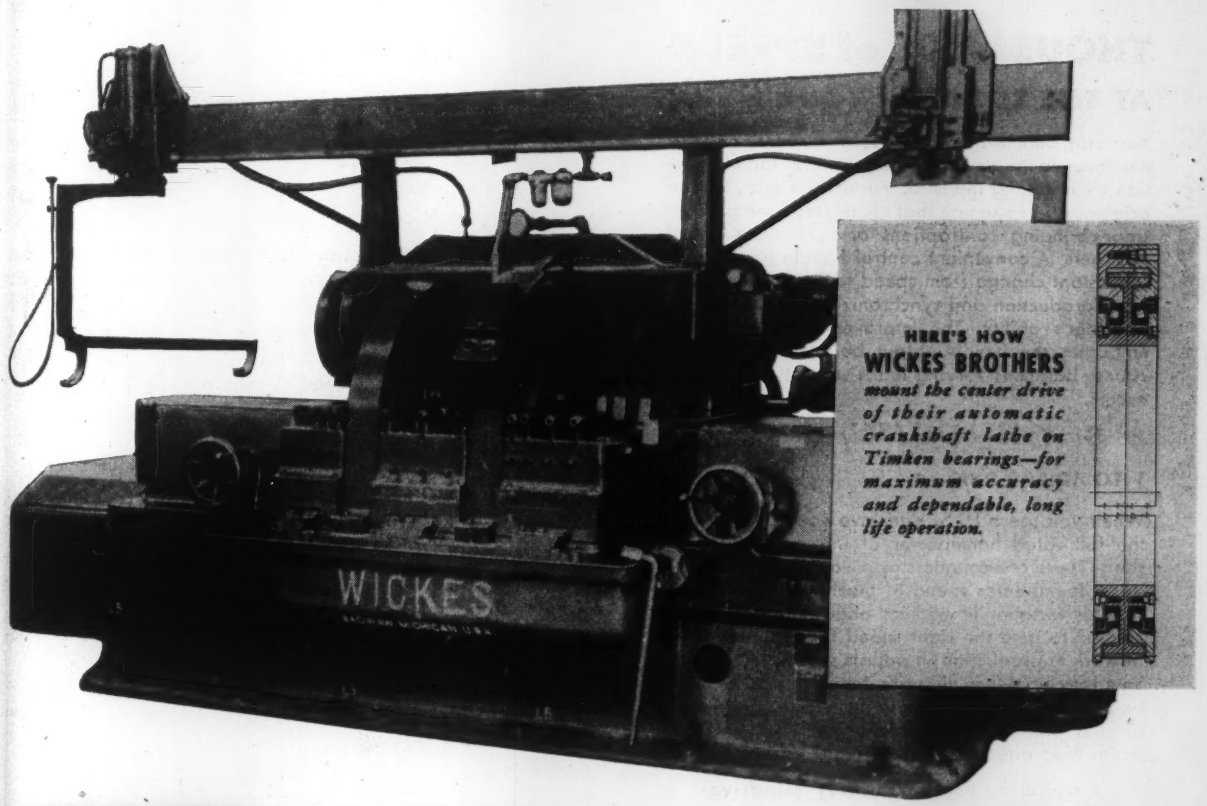
WITH a center drive crankshaft lathe like the one shown below, continued accuracy and high speed production depend largely on the big bearings in which the center chuck revolves. For maximum precision and dependable operation with minimum friction, Wickes Brothers mount the center drive on Timken® tapered roller bearings.

Due to the line contact between the rolls and races, Timken bearings have extra load-carrying capacity—give the center chuck maximum support. The work is held in proper position. The tapered construction of the bearings enables them to carry both radial and thrust loads—in any combination.

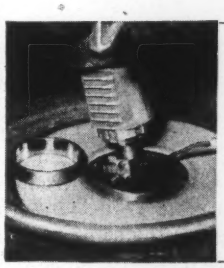
Timken bearings are precision products throughout. The rolls and races are made of Timken fine alloy steel for toughness, then case-hardened for exceptional resistance to wear. True rolling motion, and incredible smoothness of rolls and races results in virtually friction-free operation.

Over the years, the dependable performance and public acceptance of Timken bearings have made Timken-equipped products first choice throughout industry. Timken bearings help build greater preference for your product among customers. When you specify bearings, specify "Timken". And when buying new equipment, make sure it is Timken bearing equipped. Look for the trade-mark "Timken" on the bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



HERE'S HOW
WICKES BROTHERS
mount the center drive of their automatic crankshaft lathe on Timken bearings—for maximum accuracy and dependable, long life operation.



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The Timken Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

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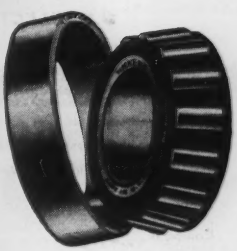

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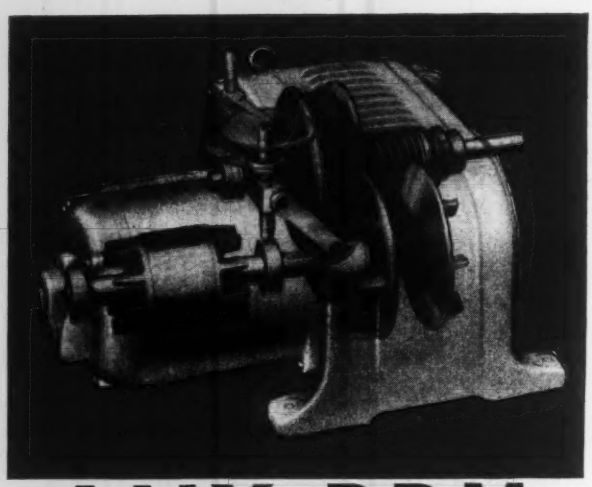

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Bevel Gear Trains

(*Concluded from Page* 110)

The solution

$$\tan \gamma_1 = \frac{c \sin \gamma}{1 + c \cos \gamma} \quad \ldots\ldots (22)$$

An example will show the application of these criteria. For $\gamma = 90$ degrees and $c = 4$, γ_1 will be above 90/2 degrees (45 degrees) and smaller than $\tan \gamma_1 = 4$, (76 degrees); this is true for the case of $b = ½$, where γ_1 was found to be about 61 degrees, as shown in the diagrams *Figs.* 2 and 4.

The diagram, *Fig.* 4, shows the special case that the sine curves are nearly linear at the point of intersection, so that it may be possible to replace the sine by the radian; this may be permissible here, even with relative large angles, as the equation contains only the differences of radians.

The approximate equation (see Equation 19)

$$r (\gamma_1' - \varepsilon) = (\gamma - 2 \gamma_1') \quad \ldots\ldots (23)$$

can easily be solved for γ_1':

$$\gamma_1' = \frac{\gamma + \varepsilon r}{r + 2} \quad \ldots\ldots (24)$$

In the foregoing example, with $\gamma = 90$ degrees and $\epsilon = 76$ degrees, this gives the same solution, $\gamma_1 = 61$ degrees, as shown in the two graphs. For a better approximation, the sine can be expressed as part of an infinite series of the radians, i.e., $\sin x = x - 1/6\, x^3$. This gives the second approximation:

$$\gamma_1'' = \gamma_1' - \frac{r (r^2 - 1) (\gamma - 2\varepsilon)^3}{6 (r \div 2)^4} \quad \ldots\ldots (25)$$

The remainder is, in the case of the example, 0.005 radian or 20 seconds, but it can attain higher values.

SPECIAL CASE $\gamma = 180$ DEGREES: A special case often arising in bevel gear design, especially in the case of planet bevel gears, is when $\gamma = 180$ degrees. This problem, *Fig.* 5, can be solved by similar considerations.

Introducing in Equation 11 $\gamma_2 = 180 - \gamma_1$, this giving $\sin \gamma_2 = \sin \gamma_1$ and $\cos \gamma_2 = - \cos \gamma_1$, the equation reads

$$b \sin \gamma_1 - \sin \gamma_1 \cos \gamma_1 = a \sin \gamma_1 + \cos \gamma_1 \sin \gamma_1$$

$$(b - a) \sin \gamma_1 = 2 \cos \gamma_1 \sin \gamma_1$$

As $\sin \gamma_1$ is not zero,

$$\cos \gamma_1 = - \cos \gamma_2 = \frac{b - a}{2} = \frac{b}{2} (1 - c) \quad \ldots\ldots (26)$$

The same result could be obtained when introducing $\gamma = 180$ degrees, $\tan \epsilon = \pm 0$, and $r^2 = (b - a)^2$ in Equations 17 and 18; this gives the same result as above. The approximate solution according to Equations 23 and 25 is not more useful for these extreme cases, but it helps in finding the range in which the angle can be expected.

Where does felt serve in your factory?

There isn't a plant in this country that does not make use of felt in some way. It is one of the hidden but important engineering materials that help industry make better products and improve plant operations. In an automobile, for example, there are some 90 different applications of felt, and in an automobile plant at least another 90. Many of these are not apparent by casual inspection but long life, smooth performance, freedom from vibration and positive lubrication are frequently the result of well engineered, reliable felt parts. Check your plant and your products – are you making full use of the many advantages offered by felt?

1 MOTORS 2 VIBRATION MOUNTINGS 3 SHOCK DAMPENERS 4 GENERATORS 5 OIL BURNERS 6 HANGER OILERS 7 BALL BEARINGS 8 ROLLER BEARINGS 9 WORKERS FLOOR PADS 10 BUFFING WHEELS 11 CASTERS 12 TRUCKS 13 PASSENGER CARS 14 TRACTORS 15 FAUCETS 16 OIL RETAINERS 17 DUST SHIELDS 18 WORK SHOES 19 OIL WIPERS 20 FILTERS 21 VENTILATORS 22 WICKS 23 THERMAL INSULATION 24 GRINDING 25 GOGGLE SHIELDS 26 FOUNDRY GLOVES 27 RESPIRATORS 28 SANDER BELTS 29 HOSPITAL SUPPLIES 30 COMMISSARY EQUIPMENT 31 WEATHERSTRIP 32 BULLETIN BOARDS 33 SWITCH BOARDS 34 RELAY BOARDS 35 TELEPHONES 36 TELETYPE 37 TELEGRAPH 38 P. A. SYSTEM 39 RADIOS 40 BUSINESS MACHINES 41 TYPEWRITERS 42 DUPLICATING MACHINES 43 POLISHING 44 CHAIR PADS 45 LEDGER CORNERS 46 DOOR BUMPERS 47 GLASS DESK TOP STRIPS 48 BLOTTER PADS 49 TABLE TOPS 50 AIR CONDITIONING 51 COLD LINE INSULATION 52 SOUND ABSORPTION 53 ASH TRAY BASES 54 CIGAR LIGHTERS 55 LAUNDRY EQUIPMENT 56 INSULATION 57 SEWING MACHINES

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The full benefit of these features shows up in the long, trouble-free protection given your equipment by Orange Roller Bushings. Next time your designs call for needle bearings, consult with our local representative on the advantages of using Orange Roller Bushings. Write for detailed Engineering Data Book showing dimensions, capacities, installation data, etc.

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has been using Orange Roller Bushings in steering controls and chain idler sprockets for over three years with complete satisfaction. Reason? "Compactness and closer alignment of rollers" writes General Excavator Company, pioneer in small excavating equipment.

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SALES AND SERVICE PERSONNEL

APPOINTMENT of personnel to manage the newly-acquired vinyl plastics operations of the Naugatuck Chemical division, United States Rubber Co., was announced recently by **John P. Coe,** vice president and general manager of the division. **Harold M. Parsekian** has been named manager of vinyl sales and will direct a national sales organization under **George R. Vila,** Naugatuck Chemical's general product manager for colloids and plastics. **Clayton F. Ruebensaal** was appointed vinyl operations manager, co-ordinating production, engineering and research, and **M. N. Hilseberg** will be manager of the Baltimore office. The rubber company's recent acquisition also includes the Marvinol plant in Painesville, O.

♦

James P. Stewart, vice president and manager of the commercial sales division of De Laval Steam Turbine Co., has been elected executive vice president. He will also continue as manager of the division. Mr. Stewart's experience includes several years with De Laval and seventeen years with the Elliott Co. of Jeannette, Pa. and Borg-Warner Corp. of Milwaukee.

♦

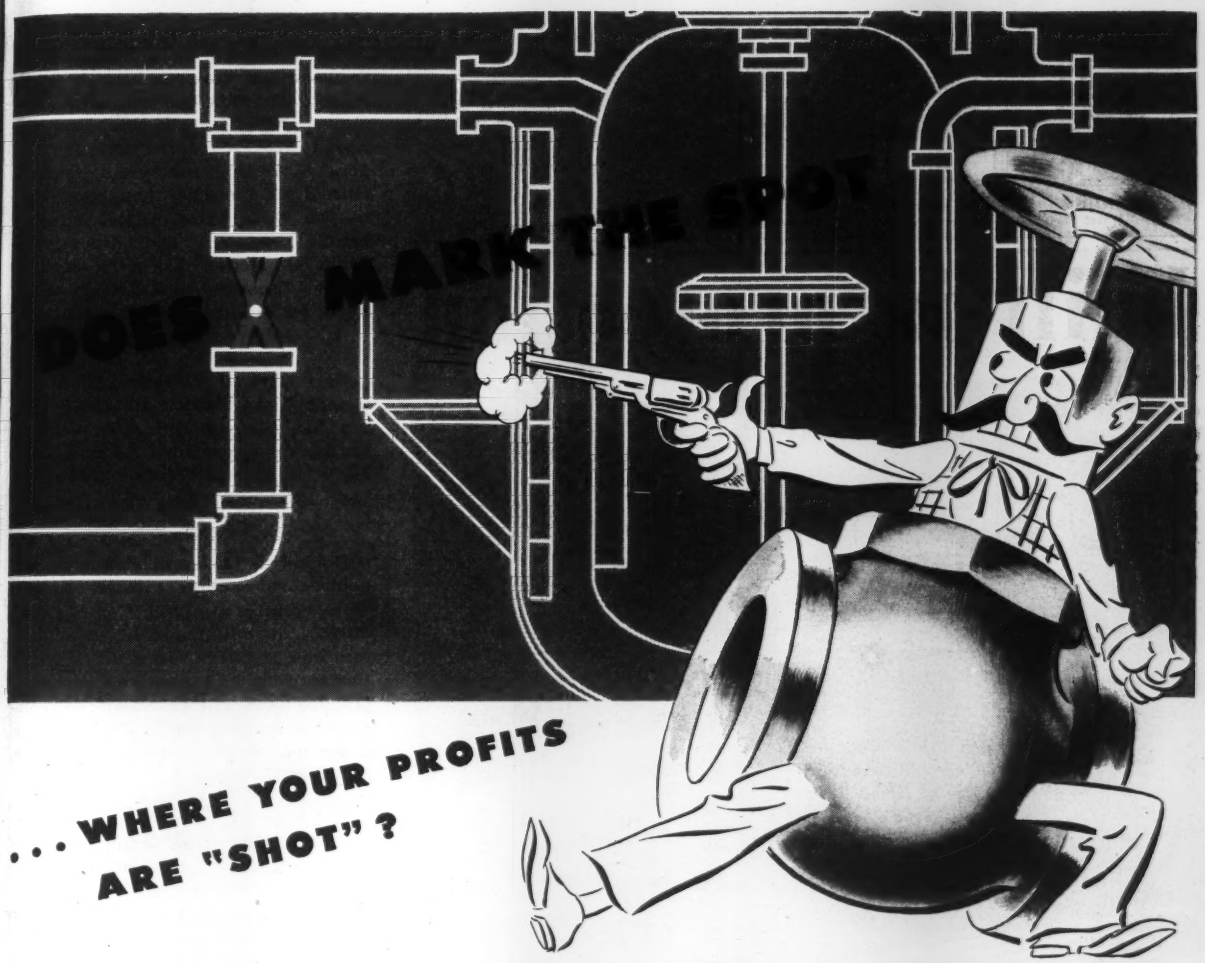
Formerly a field service engineer, **W. M. Bertolet** has been appointed testing equipment sales engineer in Cleveland for the Baldwin Locomotive Works of Philadelphia.

♦

With headquarters in Detroit, **Glenn A. Caldwell** has been appointed engineering supervisor of the Detroit engineering and service department of Westinghouse Electric Corp. He has worked for the company since 1927, having joined Westinghouse as a graduate student trainee.

♦

The Falk Corp., Milwaukee, recently appointed **Arthur L. Larson** assistant to the sales manager. He was also promoted to the position of manager of the sales inquiries division. **William J. Urban,** former special representative in coupling sales, has been appointed manager of coupling sales. New manager of distributor sales is **Don K. Lambert,** who



. . . WHERE YOUR PROFITS ARE "SHOT" ?

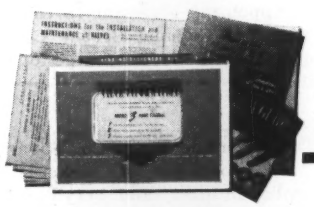
In plans for any valve-equipped product, the "X" that indicates a valve frequently marks the spot where profits disappear. If the valves selected are second-rate, continuous, costly servicing can wipe out "savings" in initial cost, cut into profits and—*most important*—sour customers on an otherwise fine product.

To protect your investment, and customer goodwill, let "X" equal a known *quality* — the recognized top-quality of Jenkins Valves. Jenkins' long experience in supplying valves for all types of products in which fluid control is a function of operation is your assurance of bed-rock servicing expense.

The customer-confidence that industry-wide advertising has established for Jenkins Valves, moreover, is a definite sales advantage. To your prospects, the familiar Diamond trade mark means not only faultless *valve* performance, but quality construction throughout your product.

Add the valve know-how of Jenkins Engineers, always ready to work with you on any problem of selection or application, and you can see why, more and more, product development men specify Jenkins whenever valves are indicated. In planning new products or redesigning present equipment, give your product and its purchasers the *extra value* of Jenkins Valves . . . *it costs no more.*

Jenkins Bros., 80 White St., New York 13
Jenkins Bros., Ltd., Montreal.



SEND FOR JENKINS DESIGNERS' KIT. A handy file of valve information needed by product development men . . . helps answer the question, "Which type of valve where for best performance?" It's yours FREE — mail coupon.

JENKINS BROS., 80 WHITE ST., NEW YORK, 13

Please send me the Jenkins Designers' Kit.

Name.....

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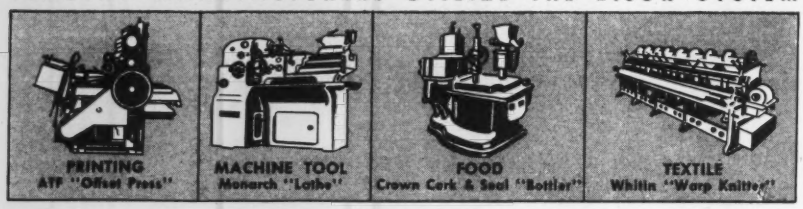
JENKINS VALVES

LOOK FOR THE DIAMOND MARK

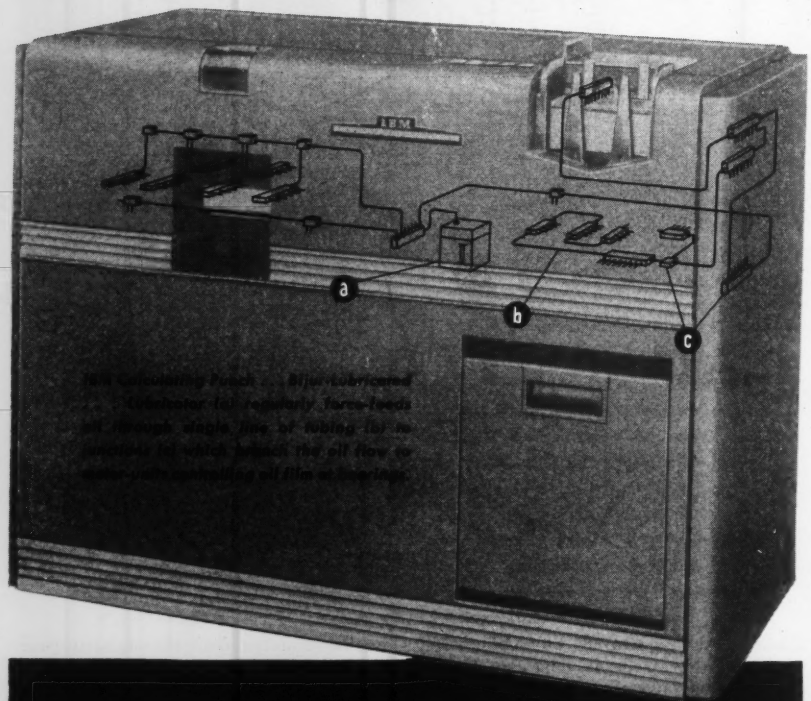
TRADE JENKINS MARK

Jenkins Bros.

LEADING MANUFACTURERS UTILIZE THE BIJUR SYSTEM



built-in protection



over 100 bearings lubricated...automatically

All 109 bearings of this machine must be oiled at once *during operation* to maintain continuous production. The Bijur system does the job by connecting all bearings to one lubricator, driven by the machine.

No sign of a system is seen outside the machine as it is completely built in at time of manufacture. This makes for a compact internal design and a clean-lined exterior. All bearings are oiled at once, yet each one receives individual attention from Bijur, the system with positive Meter-Unit control of oil flow *at the bearings.*

For further details write for "The ABC of Modern Lubrication."

388

The correct oil film to each individual bearing... automatically

BIJUR
LUBRICATING CORPORATION

LONG ISLAND CITY 1, NEW YORK

was formerly special representative in the distributor sales division. Three former sales trainees have been appointed to Falk district sales office staffs. **Nile E. Sweet,** special representative, distributor division, has gone to Detroit for special training. **Harold C. Fleischer** has transferred to the New York district office to handle inquiries and orders, and **Elliot G. Heuser** has been assigned to the Wisconsin sales division headed by **L. H. Billing,** sales representative.

♦

Formerly chief engineer, A. S. Campbell Co., Boston, **Charles I. Geddes** has been named sales engineer for Rollins Engine Co., Nashua, N. H. He will represent Rollins throughout New England.

♦

Donald S. Leonard has been appointed sales representative for the United States Graphite Co., Saginaw, Mich., and will make his headquarters in Pittsburgh. In addition to the territory in and around Pittsburgh, Mr. Leonard will represent his company in northwestern Pennsylvania, a portion of Maryland and Virginia, and West Virginia.

♦

Having served as acting manager of the clad and conversion sales department of Lukens Steel Co., Coatesville, Pa., **William J. Powers** has been appointed manager of the department. Mr. Powers began his association with Lukens in the engineering department of Lukenweld division, was transferred to alloy sales, became a salesman and, later, assistant sales manager. He has been acting manager of alloy sales since July, 1949.

♦

George L. Carr, for the past thirteen years vice president and sales manager of Apex Broach Co., has been appointed assistant to the sales manager of Colonial Broach Co., Detroit. He will be in charge of estimating.

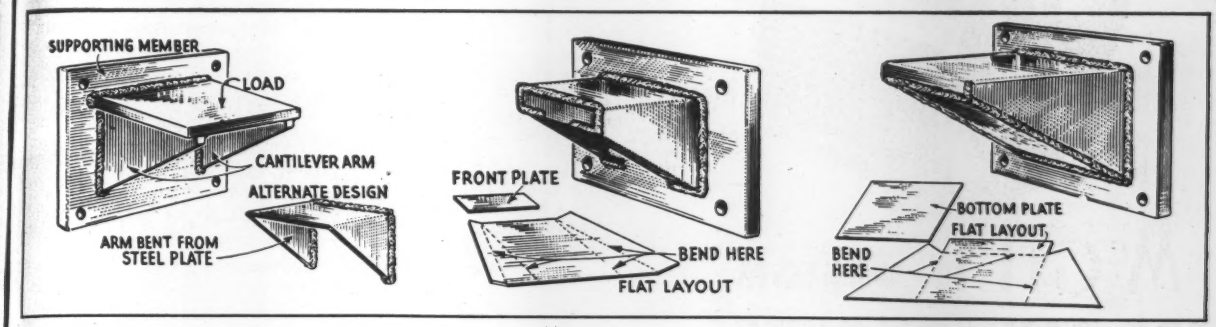
♦

The Riverside Metal Co., Riverside, N. J., producers of nickel-silvers, phosphor-bronzes, and beryllium-copper, has recently appointed **Fred M. Shelley Jr.** and **Alfred G. Dennison** to the posts of general sales manager and assistant general sales manager, respectively. Mr. Shelley is one of Riverside's oldest employees, this being his thirtieth year with the firm. He set up the company's first regional sales office in the New York area in 1919 and prior to that was

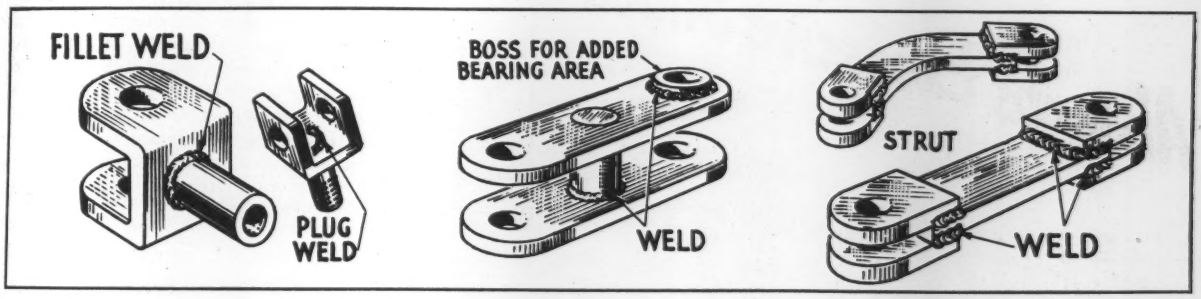
XUM

Welded Design Builds These Parts Stronger and at Lower Cost

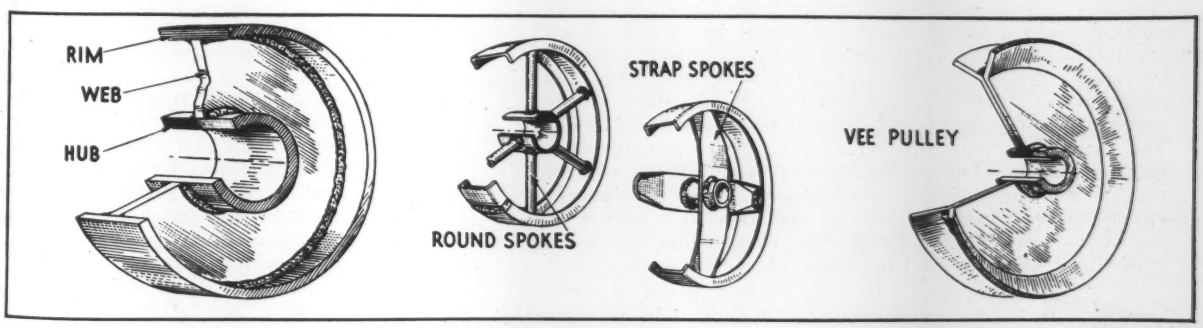
BRACKETS



LINKS AND CLEVICES



WHEELS



BY designing component machinery parts for welded steel construction, manufacturers today are using less material, achieving greater strength, eliminating the need for patterns and thus are lowering their production costs. Many are following the simple approach to redesign of existing machinery by changing over one part at a time, assuring continuous production during reconversion.

In the production of welded steel machinery parts components are generally cut or sheared from plain steel shapes or from plate, then held in simple clamp-type fixtures and weld-assembled with fast, easy, down-hand techniques.

THOUGHT STARTERS FOR MACHINE DESIGN

For free data sheets on welded machine design, write

THE LINCOLN ELECTRIC COMPANY

Dept. 13, Cleveland 1, Ohio

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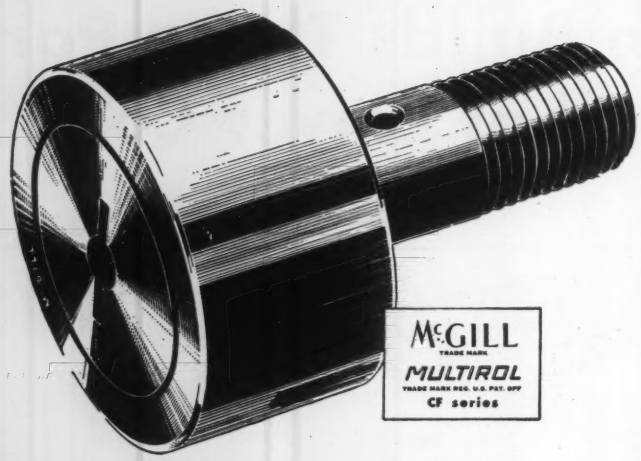
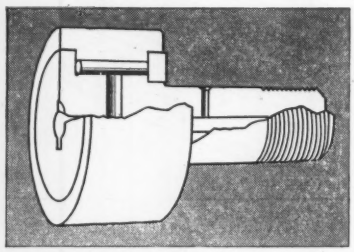


McGILL DESIGN FOR CAM FOLLOWERS

Absorbs Excessive Shock Loads



You can see at a glance the ruggedness of construction which enables Multirol CF Series bearings to take repeated shock loads, even at the increased speeds demanded by modern machines. The extra heavy outer race section has a case hardened surface which provides extra wear, and a tougher core to resist shock loads. The inner race and flange, with hardened wear surfaces, are made of a single piece with the stud, preventing any possibility of disassembly in operation. Notice there are no delicate parts or washers anywhere, to break or cause trouble. The many full type small diameter rollers provide extra bearing surface. They are finished to precision limits assuring friction-free operation between the smooth ground raceways. Nearly twenty years successful operation in a variety of installations has proved the quality, construction and workmanship of CF Series Multirol bearings.

For installations where it is necessary to mount the bearing on a shaft, this same design is available in the Cam Yoke Roller (CYR) Series. For complete information about either type write McGill Mfg. Co., Inc., Bearing Division, 200 N. Campbell St., Valparaiso, Indiana. Ask for Bulletins CF-40 or CYR-47.

McGILL
TRADE MARK
precision bearings

active in the non-ferrous metals business, with Rome Hollow Wire & Tube Co. Mr. Dennison joined Riverside in 1945, having been a district manager for Wolverine Tube division of Calumet and Hecla Consolidated Copper Co.

♦

K. Kennard Gross, previously coordinating engineer, Leeds & Northrup Co., has joined Specialized Instruments Corp., Belmont, Calif., as Eastern service engineer for Spinco ultracentrifuges. His headquarters will be in Philadelphia. During the war, Mr. Gross was a project engineer at Wright Field, Dayton, O., working on instrumentation for aircraft rotating and jet power plants and has also been associated with Morris Newmark and Proctor & Schwartz Electric Co., both of Philadelphia.

♦

The recent appointment of **George C. Jelliffe** as Eastern district manager has been announced by Ilg Electric Ventilating Co. of Chicago. He first became associated with the company in February, 1946, when he was employed as an assistant to **P. D. Briggs,** vice president and general sales manager. Headquarters for the Eastern district are at 15 Park Row, New York, N. Y.

♦

Previously serving as salesman and assistant sales manager, **E. L. Johnson** has been named sales manager of the Palnut Co., Irvington, N. J., manufacturers of lock nuts and self-locking fastenings.

♦

Appointment of **Harold R. Bennett** as manager of industrial sales for Thresher Paint and Varnish Co. has been announced by **Herschel E. Post,** general sales manager of industrial finishes for Pittsburgh Plate Glass Co. Thresher Paint and Varnish Co. is a Pittsburgh affiliate. Associated with the industrial finish industry for more than twenty-five years, Mr. Bennett has been with Thresher since 1930, serving in various manufacturing, laboratory and sales capacities. As manager of industrial sales he will headquarter at Dayton, O.

♦

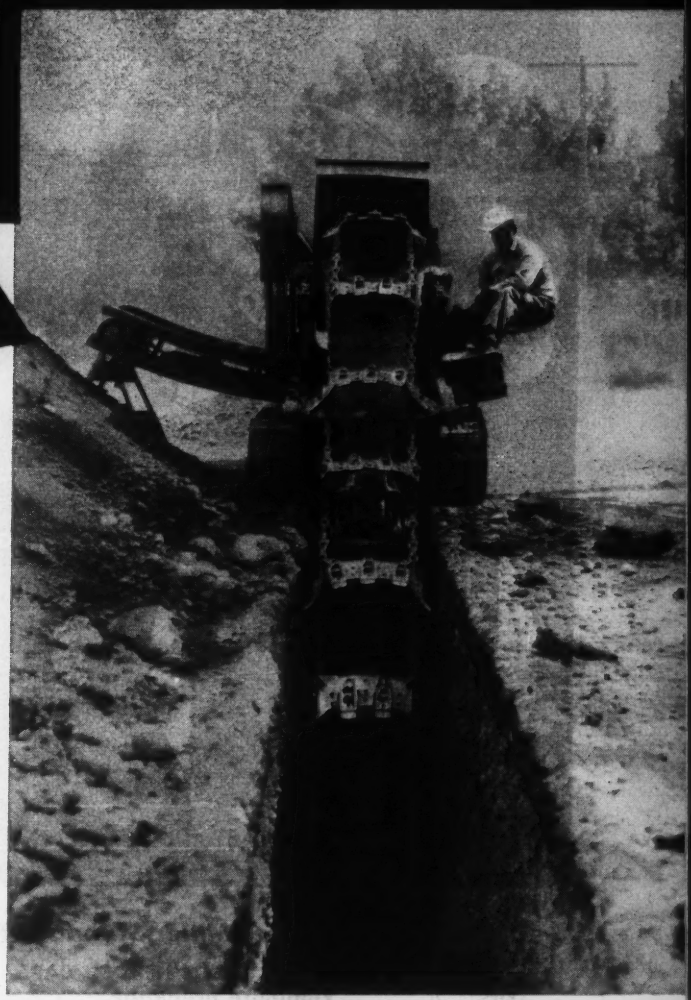
To handle sales negotiations for gas and oil pipe lines equipment and oil and gas engines for all services, **A. H. Boehm** has been made Eastern manager, engine division, Worthington Pump and Machinery Corp. He will continue to make the corporation's New York district office his

Faster Ditching...Greater Versatility

BUCKEYE 406
GENERAL UTILITY DITCHER

Another Cost-Cutting Application of

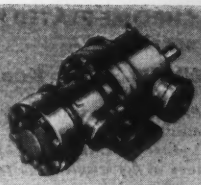
VICKERS HYDRAULICS



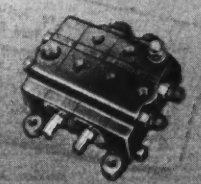
The Model 406 is a prominent member of the family of Buckeye Ditchers described as providing "The Most Ditch for the Least Money." It has a reputation for fast digging, stamina and versatility. The telescoping boom provides digging depths down to 6′ to 8′; cutting widths are from 17″ to 24″. Being exceptionally compact, the 406 works in close quarters as well as in the wide open spaces.

Vickers Hydraulics has an important part in the performance of the 406. The boom hoist is driven by a Vickers Hydraulic Motor which provides positive control at all times . . . boom cannot float or sink in ditch. Raising or lowering of boom is easily accomplished. Another Vickers Hydraulic Motor quickly shifts the conveyor from the extreme position on one side of machine to the other (or any intermediate position). When working under close or irregular conditions, this feature is invaluable in gaining clearance. The Vickers Pump shown also supplies power for the hydraulic brakes.

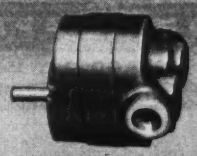
Vickers Hydraulics improves the operation of a great variety of construction machinery. Get in touch with the nearest office for information and data on Vickers hydraulic equipment designed and built expressly for construction machinery and information on other cost-cutting applications.



Vickers Double Pump consists of two vane type pumps driven from same shaft . . . providing power for two separate hydraulic circuits. Exclusive "hydraulic balance" construction assures longer pump life.



Vickers Sectional Type Multiple-Unit Valve is available in many combinations for convenient and selective control. Includes relief valve for overload protection.



Vickers Gear Type Hydraulic Motor has complete hydraulic balance (both radial and axial) that eliminates pressure loads, thus providing longer life, higher operating efficiency, greater practical operating pressure.

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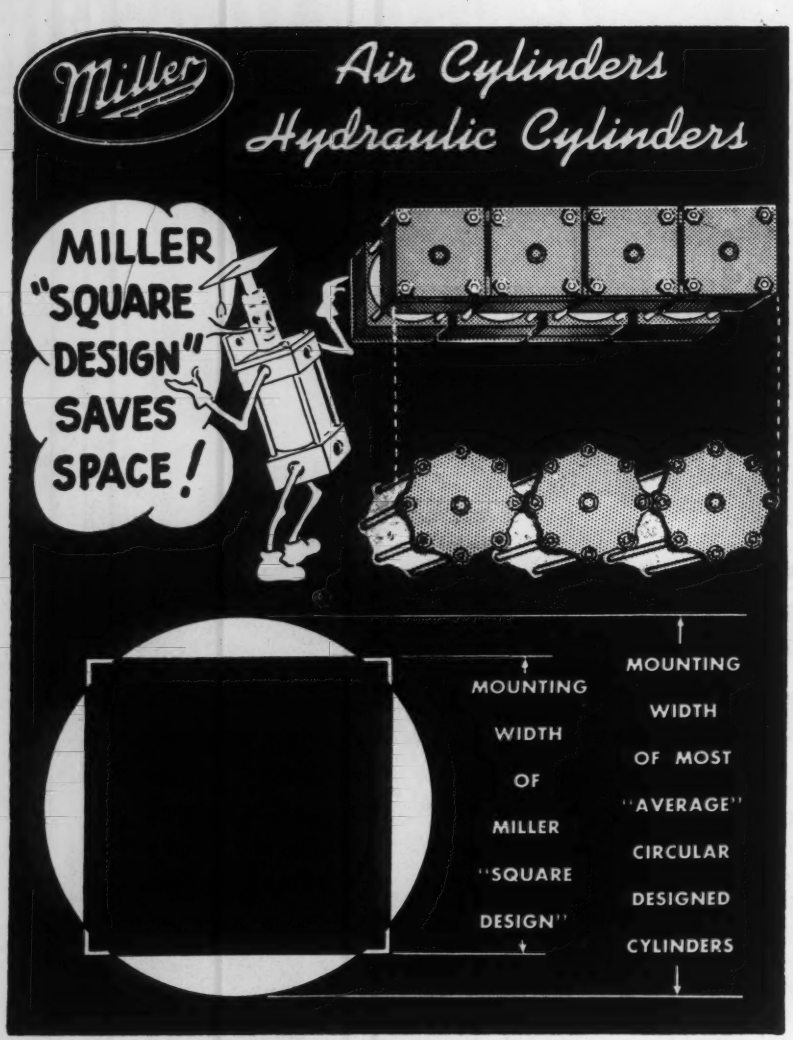
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921


Miller
Air Cylinders
Hydraulic Cylinders
MILLER "SQUARE DESIGN" SAVES SPACE!
MOUNTING WIDTH OF MILLER "SQUARE DESIGN"
MOUNTING WIDTH OF MOST "AVERAGE" CIRCULAR DESIGNED CYLINDERS

Other Outstanding Miller Standard Features . . .

- **SOLID STEEL HEADS, CAPS, MOUNTINGS. Eliminate breakage.**
- **HARD CHROME PLATED PISTON RODS. Resist nicks, scoring.**
- **DIRT WIPER SEALS. Keep out abrasive dirt.**

Miller High Pressure Hydraulic Cylinders meet the "J. I. C." Hydraulic Standards, the "quality" standards recently approved by the Joint Industry Conference (J. I. C.) of leading manufacturers and users of hydraulic equipment.

Complete Line

- **AIR CYLINDERS 1½" to 20" Bores**
- **LOW PRESSURE HYDRAULIC CYLINDERS 1½" to 14" Bores**
- **HIGH PRESSURE HYDRAULIC CYLINDERS 1½" to 12" Bores**

Single and Double Acting, Single and Double Rod End, Spring Return, Cushioned and Non-Cushioned, Over-Sized Rod, and Long Stroke Cylinders in All Mounting Styles.

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AIR AND HYDRAULIC CYLINDERS · ACCUMULATORS · COUNTERBALANCE CYLINDERS · BOOSTERS · AIR HOISTS

headquarters. Mr. Boehm has served Worthington for twenty-five years as an engine sales specialist assigned to various district offices throughout the country. He succeeds **W. L. Russell** who has been assigned to handle Canadian sales for the John Inglis Co., the company's Canadian associate.

♦

Appointments of **David Kirk Stuart** as manager of the Pittsburgh branch of the Crucible Steel Co. of America and **Richard J. Rand** as assistant branch manager were announced recently. Mr. Stuart, who has been associated with Crucible since 1933, will fill the position left open by the promotion of **John S. Billingsley** to central sales manager last August. Mr. Rand joined the company in 1940 and has served as office manager of the Pittsburgh branch since 1948.

♦

William B. Moore Jr. has joined Reynolds Metals Co. as a technical service engineer. He will be doing development work in the applications of aluminum in the chemical and petroleum industries.

♦

The B. F. Goodrich Chemical Co. has recently appointed **F. L. McNabb** to the position of staff representative for Hycar and rubber chemicals in Cleveland. Mr. McNabb has held various technical and sales positions connected with synthetic rubbers and adhesives.

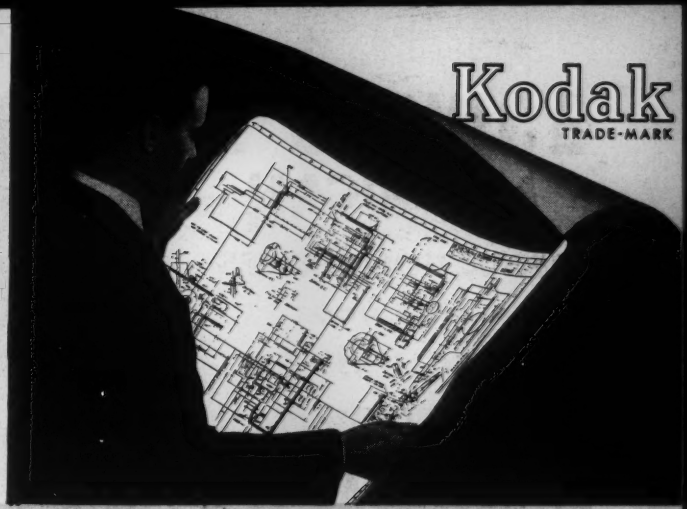
♦

Covering the territory of metropolitan New York City and northern New Jersey, **Charles J. Sauter,** 17 East 42nd St., New York 17, N. Y., is a new sales engineering representative for the Aurora Metal Co. This company has also appointed **I. R. Jones,** 925 Burmont Rd., Drexel Hill, Pa., as sales engineering representative in southern New Jersey, southeastern Pennsylvania, Delaware, and Maryland. Both of these men will represent the company for aluminum bronze and silicon bronze vacuum die castings in their respective territories.

♦

The appointment of **James D. Lowe** as wire and cable specialist has been announced by General Electric Co. Previously commercial engineer for the wire and cable division, Mr. Lowe has been assigned to the construction material department of the New York district and will make his home office at the Bridgeport plant.

IT HELPS IMPROVE PRODUCTS—High speed movies provide a record of motion far too fast to see. With the Kodak High Speed Camera, a second becomes three minutes, so you can see and analyze rapid movement—spot faulty action and points of excessive wear—see ways to make a better product.



IT COPIES DATA IN SECONDS—Engineering drawings, shop orders, specifications, records, and letters of all kinds can be copied fast, and with utmost accuracy. Photocopying with Kodagraph Papers, Cloths, and Film saves time, protects originals from wear and tear—even permits producing clean, legible copies from faded or worn material.

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HERE YOU SEE a few examples of how the speed of photography serves industry. In addition, its accuracy is used in copying drawings, documents, and data of all kinds. Its ability to reduce can put records on microfilm and save 98% of filing space.

These and the other unique qualities of photography are helping cut costs, improve products, speed production, and stimulate sales. If you would like to know more about how it could serve you, write for literature or for specific information which may be helpful to you. Eastman Kodak Company, Rochester 4, N. Y.

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IT ANALYZES CHEMICALS IN A FLASH—Spectrography with Kodak Spectrum Analysis Film and Plates quickly determines the composition of almost all materials. It provides a means to make frequent production-line analyses. It can maintain a check on specifications and speed up output.

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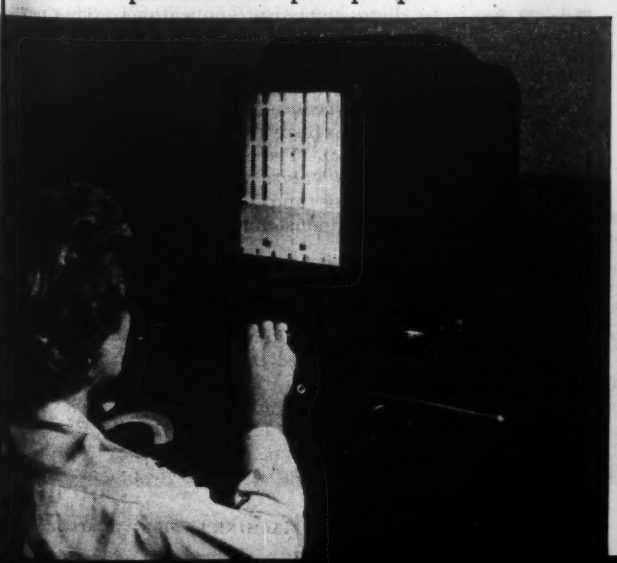

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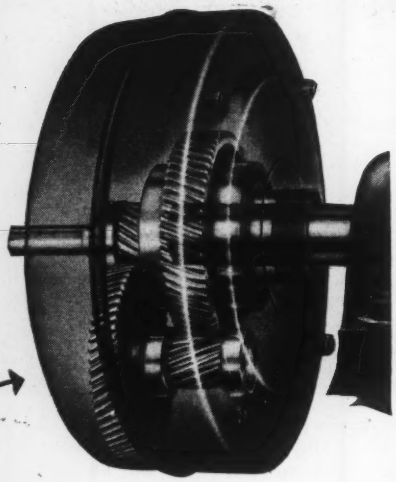
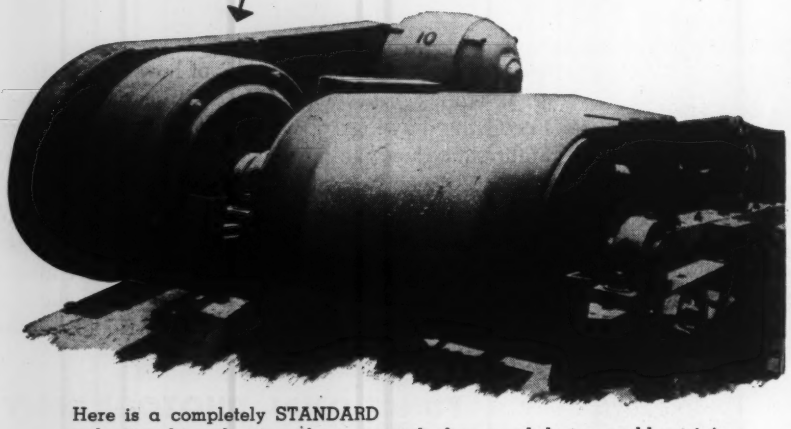
REDUCTION DRIVES give you *EXCLUSIVE* DESIGN ADVANTAGES!





Here is a completely STANDARD reduction drive that transforms special, slow-speed design problems into simple, efficient high-speed installations . . . using STANDARD motors, STANDARD V-Belts, STANDARD sheaves! Think of the design possibilities this compact drive gives you! No special engineering—no bulky foundations or supports are necessary. Six sizes of Reduction Units provide any speed below 154 rpm for drives up to 25 hp. Here's an amazingly different slow-speed drive—IT PUTS THE GEARS WHERE THEY BELONG—right on the shaft of the driven machine! Over 50,000 are already paying their way throughout industry.

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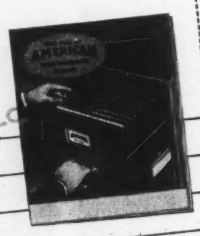
SHOW ME PROOF . . .
. . . of the unique design advantages you talk about. Please rush my free copy of The American Drives Data Book.



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SALES NOTES

AS PART of its continued sales expansion program, **Plastic and Rubber Products Inc.**, Dayton, O., has appointed **Airsupply Co.**, a division of the **Garrett Corp.**, as new West Coast distributor for O-ring seals. Airsupply will carry in stock, for immediate delivery, a wide assortment of seal sizes and will work directly with engineers on their individual O-ring application problems.

♦

New sales engineering representative for aluminum bronze and silicon bronze vacuum die castings for the **Aurora Metal Co.**, Aurora, Ill., is **Mayer & Roth**, 2007 Madison Road, Cincinnati 8, O. The territory of southern Ohio and southeastern Indiana will be served by this recently appointed representative.

♦

Opening of a sales office at 410 West First St., Dayton, O., has been announced by **Cutler-Hammer Inc.**, Milwaukee electrical manufacturers. The new office is being opened to meet the need for Cutler-Hammer motor control and allied electrical apparatus in the Dayton area. P. L. Erickson will manage the office as a branch of the company's Cincinnati district sales office.

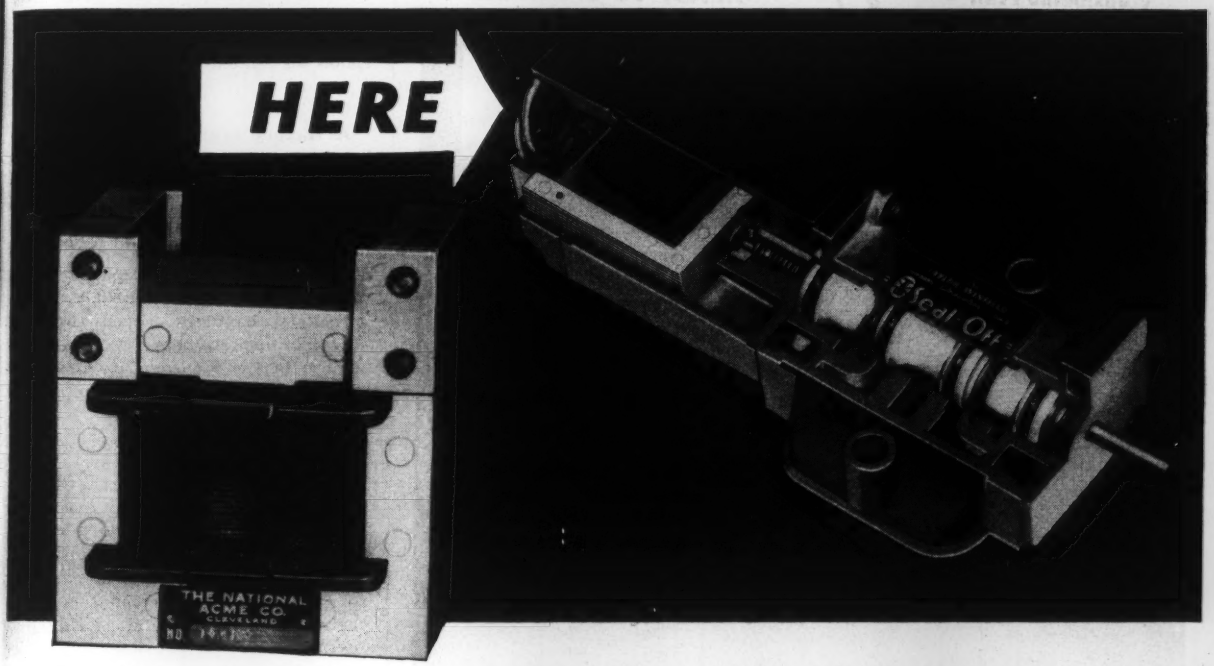
♦

Since all the time and facilities of **Saval Inc.** are now required for the production of aircraft and related units, a new company has been formed to produce Shear-Seal valves for industrial applications. This new firm, known as **Barksdale Valves** and located at 4905 Santa Fe, Los Angeles, Calif., has separate facilities to produce nonairborne valves under an exclusive license arrangement with Saval. The entire resources of Barksdale Valves will be devoted to developing and producing fluid controls for industrial applications.

♦

In order to increase its line of metal finishing chemicals, **Allied Research Products Inc.**, Baltimore, has purchased the **R. A. Hoffman Chemical Co.** of Cleveland. R. A. Hoffman, formerly owner of the Hoffman company, has joined Allied Research and will be transferred to Baltimore in charge of the development of new

FOR FAST, DEPENDABLE SERVICE



NAMCO HEAVY-DUTY SOLENOIDS
are the exclusive choice of the TAYLOR-WINFIELD CORPORATION

The Taylor-Winfield "Seal-Off" 2 to 4-Way Namco Solenoid Operated Pilot-Type Air Valves are designed to actuate air operated tools and fixtures on resistance-welding machines, presses and the like and have proved their superiority on a wide variety of high-speed, heavy-duty applications.

Namco "Stellite"-Welded Solenoids were selected for this valve unit only after exhaustive tests in the Taylor-Winfield laboratories at Warren, Ohio. This Company further states, "The low current demand of the Namco Solenoid permits control of the valve by electronic means, thus avoiding time delay of interposed relay."

If you build a product where rugged, mechanical Solenoid construction, dependable fast operation, and low current consumption are important, then you need Namco "Stellite"-Welded Solenoids—engineered for your specific application. We will be glad to have our engineers contact yours.

Complete standard range of Namco "Stellite"-Welded Solenoids are illustrated and tabulated in Engineering Bulletin EM-46A. Ask for your copy.

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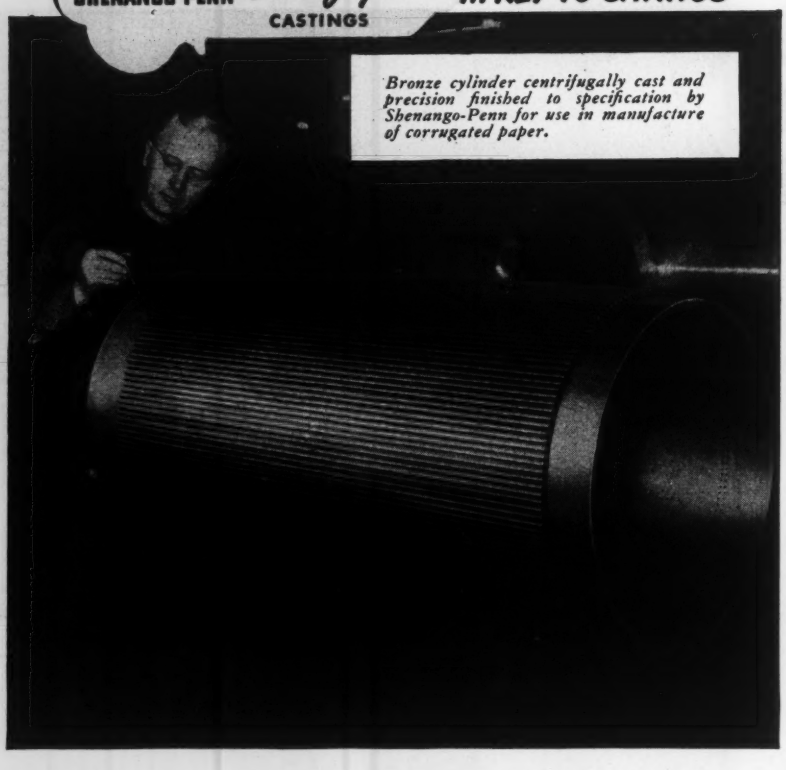
Acme-Gridley 4-6 and 8 Spindle Bar and Chucking Automatics • Single Spindle Automatics • Thread Rolling Machines Automatic Threading Dies and Taps • The Chronolog • Limit, Motor Starter and Control Station Switches • Counters • Solenoids Centrifuges • Contract Manufacturing

SHENANGO-PENN *Centrifugal* CASTINGS ... KEY TO SAVINGS



Bronze cylinder centrifugally cast and precision finished to specification by Shenango-Penn for use in manufacture of corrugated paper.

Major parts last longer ... cost less!

TAKE this special bronze forming roll cover, for example. Because it is a Shenango-Penn *centrifugal* casting, it combines complete uniformity, exceptionally fine, pressure-dense grain, and freedom from blow holes, sand inclusions and other common, often hidden defects.

The money-saving result, quite naturally, is greatly prolonged wear life and the plus strength that will take abnormal loads and speeds without risking costly failure in service.

This is just one of the countless types of cylinders, sleeves, liners, rings, rolls and roll assemblies produced by Shenango-Penn in ferrous and non-ferrous metals for various industries. When *you* need such parts . . . rough, semi-machined or precision finished, small or large . . . specify Shenango-Penn and profit by Shenango-Penn's specialized processes, facilities and experience.

MEANWHILE, ASK FOR BULLETIN

No. 143—Centrifugal castings of non-ferrous metals and alloys.

No. 144—Centrifugal and static castings of plain and alloyed irons.

No. 145—Centrifugally cast bushing stock in all standard sizes.

SHENANGO-PENN MOLD COMPANY

1282 West Third Street Dover, Ohio

Executive Offices: Pittsburgh, Pa.

SHENANGO PENN

All Bronzes • Monel Metal • Ni-Resist • Meehanite Metal ®

types of organic finishes. Prior to completion of new laboratories in Baltimore, Mr. Hoffman's former research laboratory at 224 High St., Cleveland, will be maintained as a branch of the Baltimore research division of Allied Research Products.

♦

A factory branch store and warehouse at 2630 Holmes St., Kansas City, Mo. has been opened by **Link-Belt Co.** The new branch, a two-story building with total floor area of 13,200 square feet, will carry ample stocks of conveying and power transmission machinery parts, chains, sprockets, bearings, speed reducers, elevator buckets, etc., so that customers in the Kansas City area and surrounding territory can be served promptly from local stocks.

♦

Warehouse facilities of the **Bridgeport Brass Co.** are being moved from Newark to a new and larger location at Hillside, N. J. The new warehouse will enable the company to give customers better service on their requirements of Bridgeport products and will provide more space for carrying larger stocks.

♦

Briggs-Weaver Machinery Co., 300 South Wayside Dr., Houston, Tex., has been appointed an accredited distributor for the **Republic Rubber Division** of **Lee Rubber & Tire Corp.**, Youngstown. To serve industrial plants in Houston and surrounding area, the firm will carry complete stocks of Republic belting, hose, and packing.

♦

The Tulsa, Okla., office of **Tube Turns Inc.** has been moved to 420 Wright Bldg. Robert S. Tyler Jr. is manager of the company's Tulsa office.

♦

Believed to be the first such arrangement ever devised in this field, the **B. F. Goodrich Co.**, manufacturers of all types of tires for industrial materials handling equipment, has announced a new tire and wheel analysis plan whereby any company can have its wheeled vehicles studied, recommendations being made without cost.

♦

CORRECTION: Through an error, announcement was made in our February issue of a change of address for the **Nice Ball Bearing Co.** The address of the company remains 30th and Hunting Park Ave., Philadelphia 40, Pa.

NO DOUBT you've experienced it—the real pleasure in grasping a problem, wrestling with it a bit, and then coming up with a solution. The unusual electrical insulation part shown above is a good example. It illustrates the kind of problem that could arise in your plant—and wind up in our "Imagination Department."

To make the part, the Manufacturer wanted plenty of structural strength, dielectric strength, light weight, and resistance to moisture, heat, and corrosion —all wrapped up in a material that was easy to machine. Continental-Diamond studied the problem, used a little imagination, and came up with *two* different plastics — Laminated Dilecto Tubing for the threaded section, and Celoron for the molded, macerated ring.

It's a good example of imagination at work—but it's a better example of how you, too, can depend upon C-D to engineer the right plastic for your needs. For C-D has no "axe to grind." We can recommend from five basic plastics subdivided into a remarkably wide range of grades and combinations of grades to meet your requirements. For complete engineering help or fast delivery of any grade, call your nearest C-D office, any time.

CELORON (Molded High-Strength Plastic)
MICABOND (Bonded Mica Splittings)
DIAMOND FIBRE (Vulcanized Fibre)
VULCOID (Resin Impregnated Fibre)
DILECTO (Laminated Thermosetting Plastic)

DL-2-50

BRANCH OFFICES: NEW YORK 17 • CLEVELAND 14 • CHICAGO 11 • SPARTANBURG, S. C. • SALES OFFICES IN PRINCIPAL CITIES.
WEST COAST REPRESENTATIVE: MARWOOD LTD., SAN FRANCISCO 3 • IN CANADA: DIAMOND STATE FIBRE CO. OF CANADA, LTD., TORONTO 8

Continental-Diamond FIBRE COMPANY

Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK 23 DELAWARE

Varo Static Converters change alternating to direct current for aircraft use with *less than 1% voltage ripple.* LORD Mountings protect such precision against shock and vibration, thus insuring the user long and dependable service.

More and more manufacturers of sensitive equipment appreciate the customer satisfaction which LORD Vibration-Control Mountings add to their products. Builders of heavier mechanical equipment use them to provide smoother, quieter operation . . . greater sales appeal. If you are interested in product improvement, investigate LORD Mountings now.

LORD BONDED RUBBER **Vibration Control**

LORD MANUFACTURING COMPANY · ERIE, PA.

Canadian Representative: Railway & Power Engineering Corp. Ltd.

MEETINGS AND EXPOSITIONS

Mar. 28-31—

Society of the Plastics Industry. Fourth national plastics exposition to be held at the Navy Pier, Chicago, Ill. William T. Cruse, 295 Madison Ave., New York 17, N. Y., is executive vice president.

Apr. 4-8—

Cancellation of the National Production Exposition has been announced. This exposition was to be sponsored by the Chicago Technical Societies Council.

Apr. 5-7—

Midwest Power Conference sponsored by the Illinois Institute of Technology to be held at the Sherman Hotel, Chicago, Ill. Additional information may be obtained from Dr. R. A. Budenholzer, Director of the Conference, 3300 South Federal St., Chicago 16, Ill.

Apr. 10-12—

American Society of Lubrication Engineers. Fifth annual convention and third annual lubrication exhibit to be held at the Hotel Statler, Detroit, Mich. W. F. Leonard, 343 South Dearborn St., Chicago 4, Ill., is secretary-treasurer.

Apr. 10-14—

American Society of Tool Engineers. Industrial exposition to be held at Convention Hall, Philadelphia, Pa. Additional information and advance registration forms may be obtained from Harry E. Conrad, executive secretary, 10700 Puritas Ave., Detroit 26, Mich.

Apr. 12-14—

American Society of Mechanical Engineers. Spring meeting to be held at Hotel Statler, Washington, D. C. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

Apr. 17-19—

Society of Automotive Engineers. Aeronautic meeting and aircraft engineering display to be held at the Statler Hotel, New York, N. Y. John A. C. Warner, 29 West 39th St., New York 18, N. Y.., is secretary and general manager.

April 24-27—

American Management Association. 19th national packaging exposition to be held at the Navy Pier, Chicago,

Machine Work Cut 75% Cost Cut Substantially Greater Sales Appeal with STEEL CASTINGS

The pilot model of this auto trailer tow-bar was produced as a weldment. Although the weldment proved satisfactory for experimental purposes, it failed to meet marketing requirements.

Turning to steel castings, the manufacturer obtained low *finished* cost with 75% less machine work, good appearance, and accuracy with durability . . . because the steel casting was *foundry engineered* for the job.

• • •

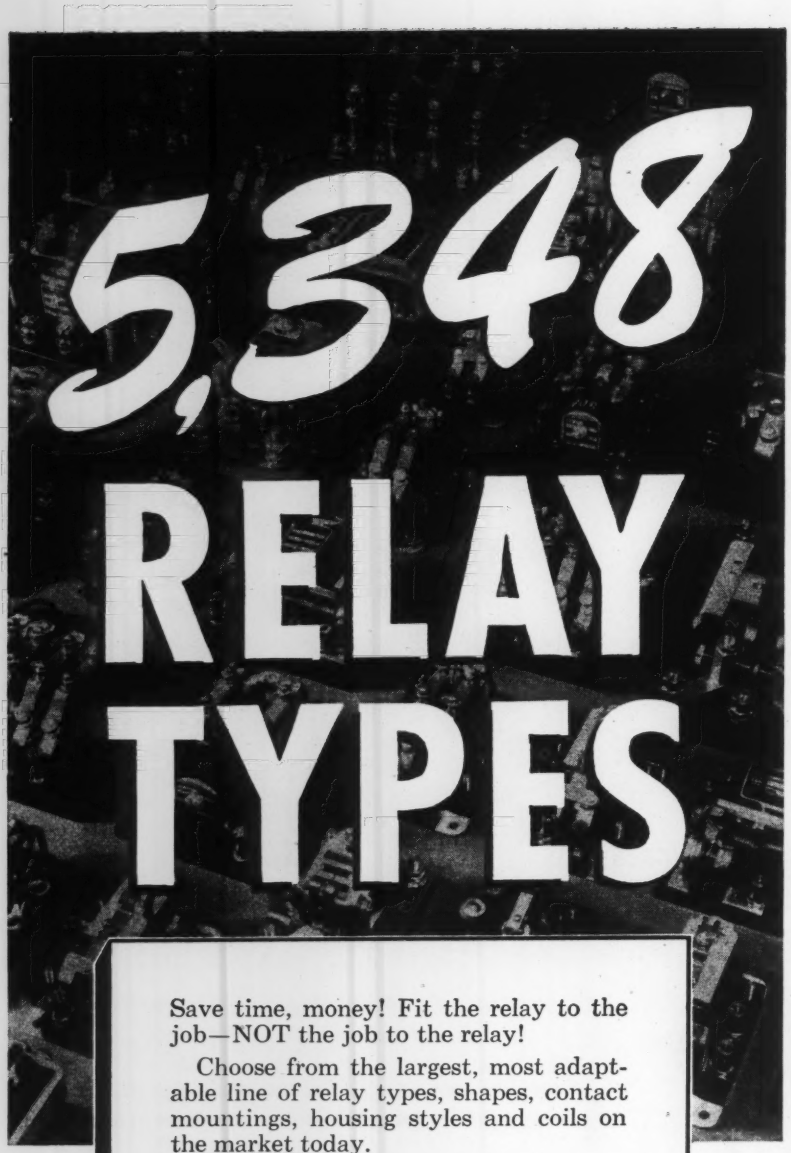
Conversion of *your* parts to steel castings may result in equal if not greater benefits than those given here.

Also in new and redesigned parts, your steel foundry engineer may be able to suggest ways to cut costs and weight and obtain other substantial benefits. Why not call him in for a discussion *while your product is still on the drawing board.*

This service is offered without cost or obligation. It makes available through your foundry engineer the full results of the development and research program carried on by Steel Founders' Society of America.

STEEL FOUNDERS' SOCIETY OF AMERICA
920 Midland Building Cleveland 15, Ohio

Design and Build With Steel Castings



Save time, money! Fit the relay to the job—NOT the job to the relay!

Choose from the largest, most adaptable line of relay types, shapes, contact mountings, housing styles and coils on the market today.

Let Struthers-Dunn engineers recommend *exactly* the right relay for your application.

Write for Catalog G for a quick guide to the most widely used of Struthers-Dunn's 5,348 relay types.

STRUTHERS-DUNN

Struthers-Dunn, Inc., 150 N. 13th St., Phila. 7, Pa.

BALTIMORE • BOSTON • BUFFALO • CHARLOTTE
CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DETROIT
KANSAS CITY • LOS ANGELES • MINNEAPOLIS • MONTREAL
NEW ORLEANS • NEW YORK • PITTSBURGH • ST. LOUIS
SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

Ill. Edward K. Moss, 330 West 42nd St., New York 18, N. Y., is public relations director.

Apr. 25-26—

Metal Powder Association. Sixth annual meeting to be held at the Book-Cadillac Hotel, Detroit, Mich. Additional information may be obtained from headquarters of the society at 420 Lexington Ave., New York 17, N. Y.

May 8-12—

American Textile Machinery Exhibition to be held in Atlantic City Auditorium, Atlantic City, N. J., under the sponsorship of the National Association of Textile Machinery Manufacturers. E. Kent Swift, Whitinsville, Mass., is president.

May 8-19—

British Industries Fair to be held at Olympia and Earls Court, London; and at Castle Bromwich, Birmingham, England. Additional information may be obtained from British Information Services, 30 Rockefeller Plaza, New York 20, N. Y.

May 29-June 9—

Canadian International Trade Fair to be held at Toronto, Canada. Additional information may be obtained from the International Trade Fair, Exhibition Grounds, Toronto, Canada.

June 4-9—

Society of Automotive Engineers. Summer meeting to be held at French Lick Springs Hotel, French Lick, Ind. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

June 26-30—

American Society for Testing Materials. 53rd annual meeting and ninth exhibit of testing apparatus and related equipment to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Robert J. Painter, 1916 Race St., Philadelphia 3, Pa., is assistant to the secretary.

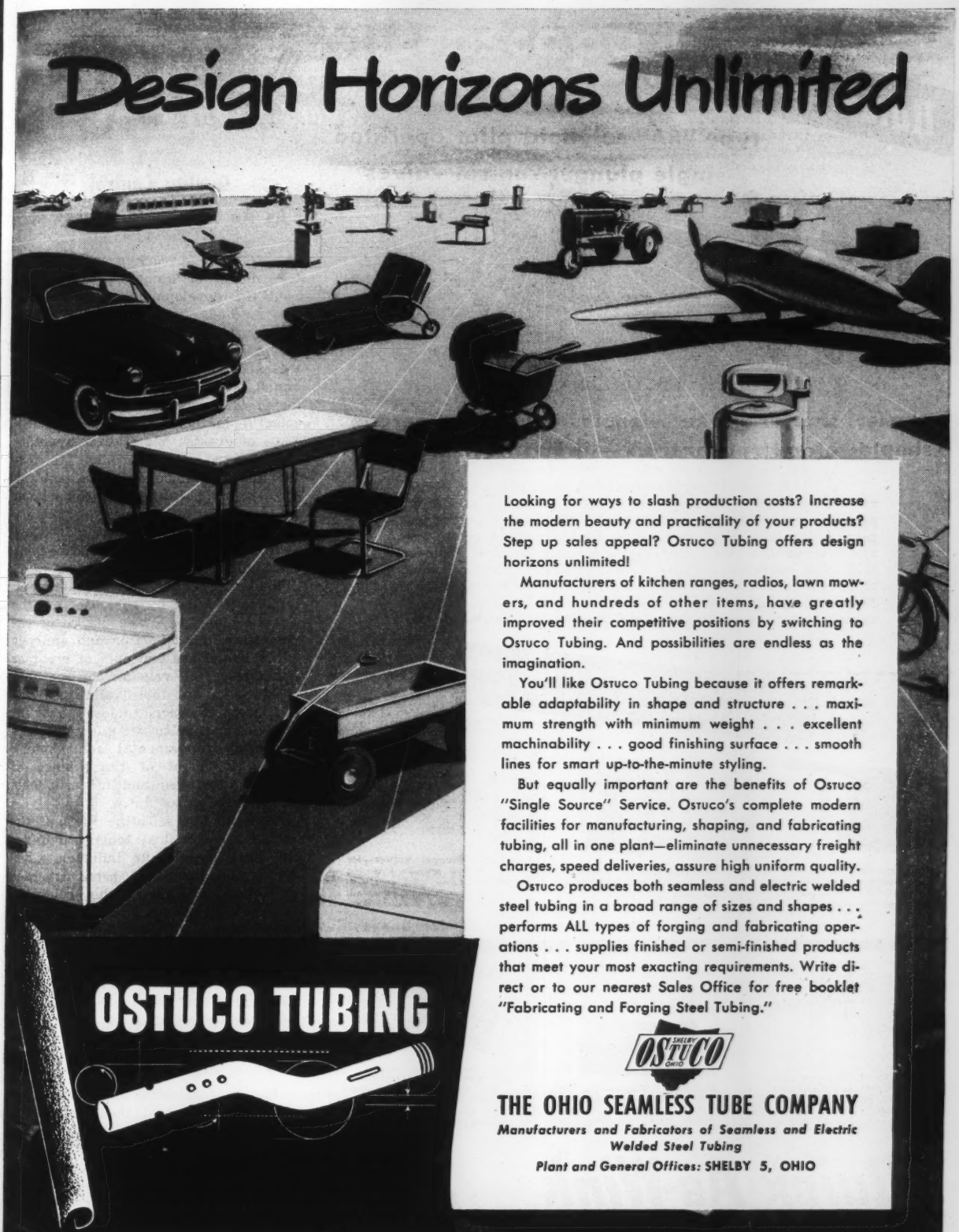
Aug. 7-19—

International Trade Fair to be held in the Coliseum, Arena, International Ampitheater and Navy Pier, Chicago, Ill. Additional information may be obtained from the First United States International Trade Fair, 10316 Merchandise Mart, Chicago 54, Ill.

Aug. 14-16—

Society of Automotive Engineers. West coast meeting to be held at the Biltmore Hotel, Los Angeles, Calif. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Design Horizons Unlimited



Looking for ways to slash production costs? Increase the modern beauty and practicality of your products? Step up sales appeal? Ostuco Tubing offers design horizons unlimited!

Manufacturers of kitchen ranges, radios, lawn mowers, and hundreds of other items, have greatly improved their competitive positions by switching to Ostuco Tubing. And possibilities are endless as the imagination.

You'll like Ostuco Tubing because it offers remarkable adaptability in shape and structure . . . maximum strength with minimum weight . . . excellent machinability . . . good finishing surface . . . smooth lines for smart up-to-the-minute styling.

But equally important are the benefits of Ostuco "Single Source" Service. Ostuco's complete modern facilities for manufacturing, shaping, and fabricating tubing, all in one plant—eliminate unnecessary freight charges, speed deliveries, assure high uniform quality.

Ostuco produces both seamless and electric welded steel tubing in a broad range of sizes and shapes . . . performs ALL types of forging and fabricating operations . . . supplies finished or semi-finished products that meet your most exacting requirements. Write direct or to our nearest Sales Office for free booklet "Fabricating and Forging Steel Tubing."

SHELBY OSTUCO OHIO

THE OHIO SEAMLESS TUBE COMPANY

Manufacturers and Fabricators of Seamless and Electric Welded Steel Tubing

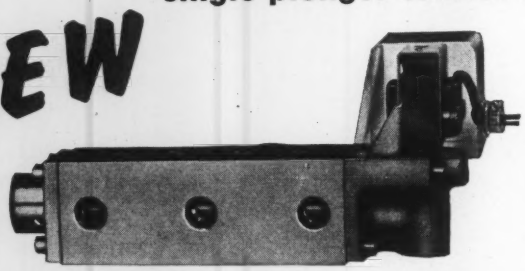
Plant and General Offices: SHELBY 5, OHIO

U. S. Sales Offices: CHICAGO, Civic Opera Bldg., 20 N. Wacker Dr. • CLEVELAND, 1328 Citizens Bldg. • DAYTON, 511 Salem Ave. • DETROIT, 2857 E. Grand Blvd. • HOUSTON, 6833 Avenue W, Central Park • LOS ANGELES, Suite 300-170, So. Beverly Drive, Beverly Hills • MOLINE, 617 15th St. • NEW YORK, 70 East 45th St. • PHILADELPHIA, 1413 Packard Bldg., 15th & Chestnut • PITTSBURGH, 1206 Pinewood Drive • ST. LOUIS, 1230 North Main St. • SEATTLE, 3104 Smith Tower • SYRACUSE, 501 Roberts Ave. • TULSA, 114 East Fifth St. • CANADIAN REPRESENTATIVE: Railway & Power Corp., Ltd., New Glasgow, Montreal, Noranda, North Bay, Toronto, Hamilton, Windsor, Winnipeg, Edmonton, Vancouver

Quick-As-Wink

type "SA" solenoid pilot operated single plunger control valves

NEW

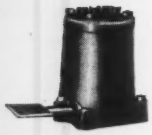


▶ smaller, shorter stroke solenoids — lower amperage
▶ simpler electrical controls — high air economy...

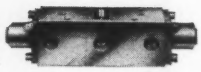
● Small solenoids traveling through only a 1/8" stroke move a small pilot valve plunger to apply air to the operating piston to move the main valve plunger. All operating parts are rugged, yet weigh only a few ounces. Reduced amperage eliminates intermediate relays, simplifying control circuits. Positive high cycle operation, without destructive impact, reduces maintenance and minimizes trouble due to voltage variations. 2-way, 3-way, 4-way and 5-way designs. 3/8" to 1" sizes, with bucking cylinder return. ***Send for Data Sheet No. 1611. It gives full details.***

Individual DATA SHEETS for Each Valve — give complete details. Write today!

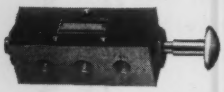
Hand Operated Air Valves—wide variety of uses. 2-way, 3-way, 4-way neutral position and compound exhaust.



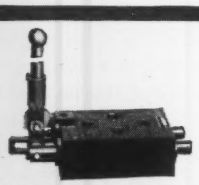
Foot Operated Air Valves—workman has both hands free, speeding production. 2-way, 3-way and 4-way actions.



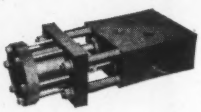
Single Plunger Valves—for air or low pressure hydraulic service. Lever, pilot, cam, diaphragm or solenoid operated. 2-way, 3-way, 4-way actions.



Series "O" and "OE" Valves—for air or hydraulic service up to 125 PSI. Push-pull, cam, pilot, diaphragm and solenoid operated. 1/8" and 1/4" pipe connections. 2-way, 3-way, 4-way and 5-way actions.



Hydraulic Valves—Up to 5000 PSI. Conservatively rated. 1/2", 3/4", 1" and 1 1/2" sizes. 2-way, 3-way, 4-way actions.



Hydraulic Valves—Up to 5000 PSI. Pilot cylinder operated. 1/2", 3/4", 1", 1 1/2" 2", 2 1/2" 3" and 4" sizes. 2-way, 3-way, 4-way actions.

Quick-As-Wink Control Valves

Manufactured by **C. B. HUNT & SON, Inc.**

1941 East Pershing Street, Salem, Ohio

DESIGN ABSTRACTS

Quality Control As An Aid To Management

AMONG the very great achievements of human progress has been the development of the scientific method. In essence, the scientific method involves the process of reaching conclusions from reproducible experiment and not from opinion, hunch, mysticism, folklore, or other forms of guesswork. In detail, the scientific method follows a well-known cycle of events: We state a hypothesis; design and experiment to test the hypothesis; collect data, analyze the data and draw conclusions from the data; then affirm, deny, or modify the hypothesis. We thereupon state a further hypothesis, and the cycle starts all over again.

The science of statistics plays an important role in the use of the scientific method. The design of experiments, the collection and analysis of data, and the concepts of error or significance, all rely on the methods of statistics for their validity. While the basic decision to use facts at all (rather than to use guesswork) is the truly fundamental achievement, the development of the science of statistics to collect and interpret facts is also most important.

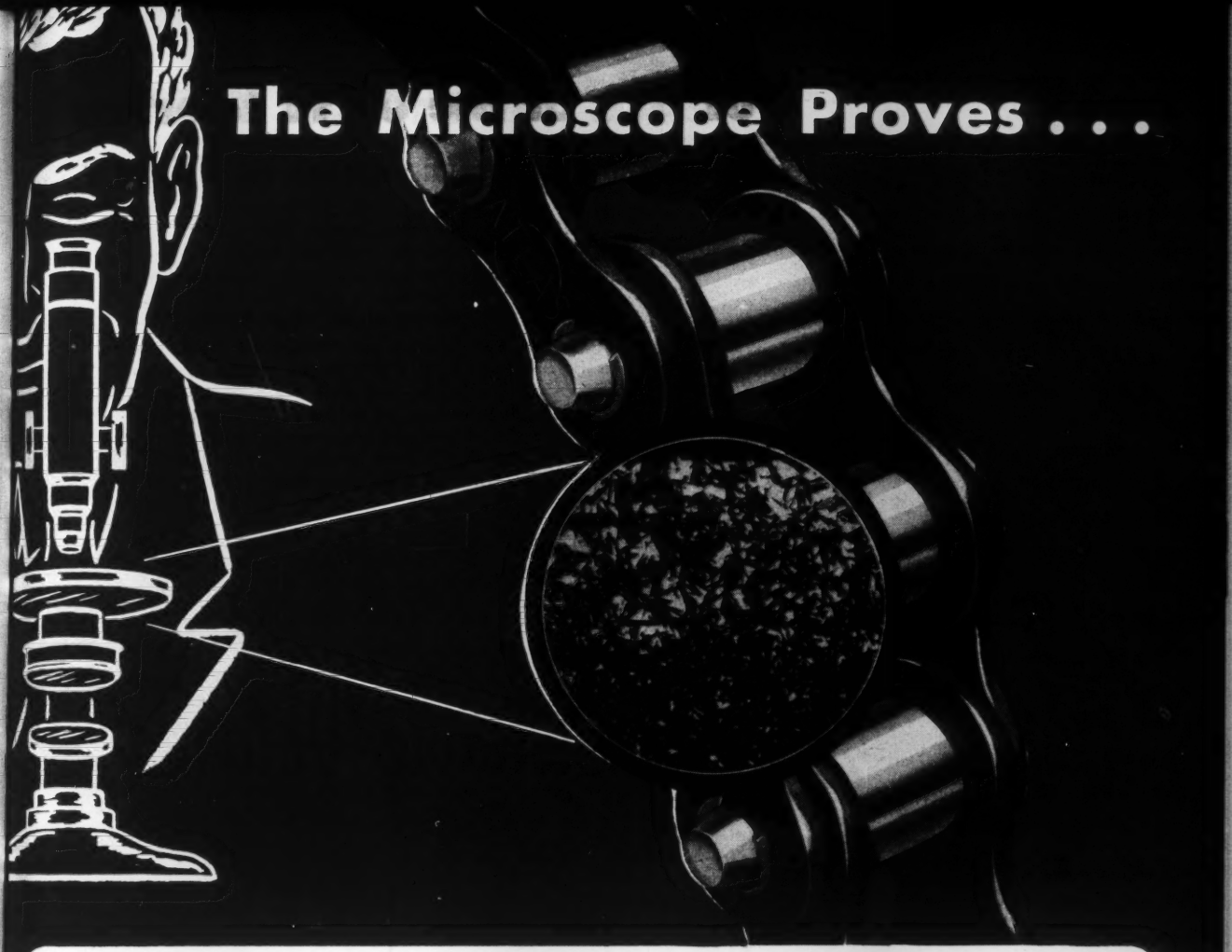
Without the scientific method the monster mechanical tools which are the skeleton of our industrial system could not have been designed and built. Without the scientific methods, the modern transport and communication necessary to feed these monsters could not have evolved. Without the scientific method, the mechanical energy required to breathe life into these tools could not have been harnessed.

Practical Benefits

Many managers of today are shocked to be told that business is managed by a methodology which has much in common with the methodology of the Middle Ages. Yet hunch, guess, suspicion, and solidified habit are the rule rather than the exception in management methodology.

Few problems in management are more naturally susceptible to scientific analysis than the problem of quality control. Inspectors and op-

(*Continued on Page* 201)



ATLAS CHAIN HAS LONGER LIFE!

Run roller chains through your hands and they all look alike. Put Atlas Chain under a microscope and you'll see the difference!

A metallographic microscope will reveal that all of the parts of Atlas Roller Chain are made of carefully selected steels . . . and scientifically heat treated for longer wear. Parts subject to excessive wear are treated to be tough by the special "Nicarb" Process. The effects of "Nicarbing" are revealed by the surface which combines the advantages of both carburizing and nitriding.

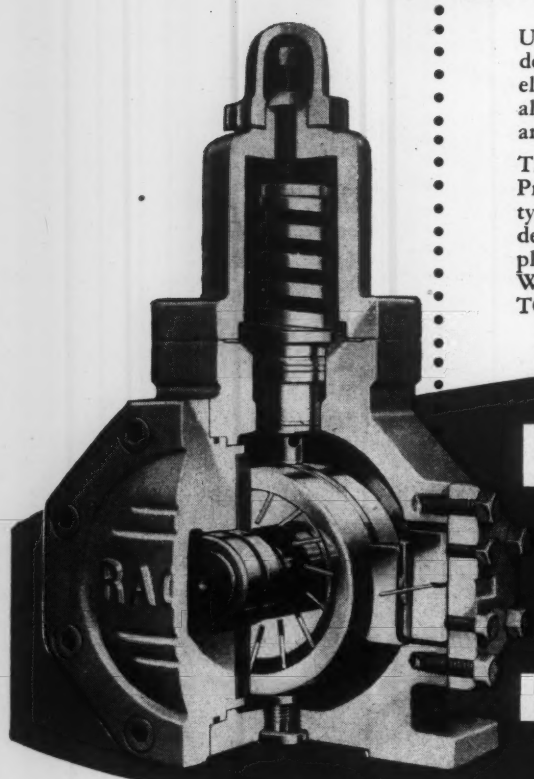
An outer rim of nitride needles knits together a base of carbide particles and binds them strongly to the core of steel. This nitride enriched outer surface, along with the binding qualities induced, proves by test to impart greater strength and wear resistance than conventional hardening. In addition, all parts take on an unusual resistance to corrosion and oxidation.

If you are interested in boosting the life of chain drives on your products or machines, take advantage of the longer life built into every link of Atlas Chain. Call in an Atlas representative for further details. Prices and specifications are available in our new catalog. Write for your free copy.

Conventional Hardening

Put ALL of the Oil to Work

Simplify the Circuit and Improve Its Efficiency



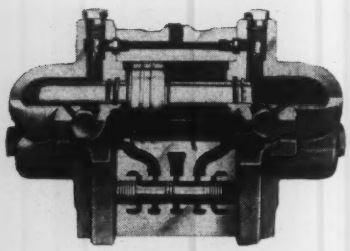
Use RACINE Variable Volume Pumps; they automatically deliver only the exact volume required. Relief valves are eliminated. Heating is reduced, horsepower saved. Overall cost of circuit components is less. These advantages are yours when you "put all of the oil to work".

The RACINE Line is complete. Pumps to 30 G.P.M. Pressure Boosters to 5000 P.S.I. Balanced piston sleeve-type 4-way valves, straight-way valves and controls, all designed for manual, electric or hydraulic operation. Complete factory and field engineering service without cost. Write for Free, complete 3-color catalog P-10-D. RACINE TOOL & MACHINE CO., 1773 State Street, Racine, Wis.

RACINE

Variable Volume

PUMPS

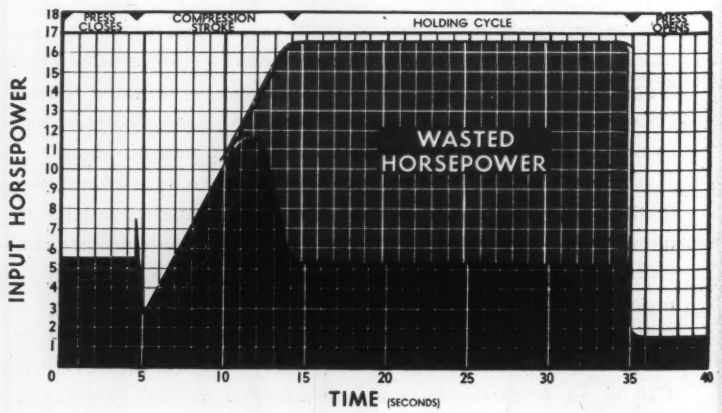


RACINE
Hydraulic BOOSTER

A 7:1 ratio pressure booster was used in the circuit in chart at right. Pump pressure of 725 p.s.i. was increased to 5000 p.s.i. with no increase in H. P. Racine Pressure Boosters are available in 3:1 to 7:1 ratio sizes

VISIT OUR BOOTH NO. 22
CONVENTION HALL
PHILADELPHIA, PENNSYLVANIA
APRIL 10-14

The black area in the chart below shows the H. P. consumed during one complete cycle of operation when a No. 6 RACINE Variable Volume Pump and 7:1 Pressure Booster is used. The red area shows the wasted additional H. P. required when an efficient 2-pressure, 2-volume Constant Volume Pump of equivalent size is used. Note the savings in H. P. Chart is based on the operation of a 200-ton molding press with a 10" ram.



RACINE

STANDARD FOR QUALITY AND PRECISION

(*Continued from Page* 198)

erators make myriads of measurements. The resultant data can disclose not only the nature of the product but also the nature of the process which made the product. Through these data:

1. The process can be improved to make the product better in the first place
2. The process can be regulated to perpetuate this improvement
3. The specifications can be improved through knowledge of process capability
4. Detail inspections can be eliminated
5. Scrap, reworks, and other losses can be minimized
6. Complaints can be reduced
7. Quality reputation can be improved.

There is nothing theoretical in the foregoing. Personally, the author has had experience with instance after instance involving many products and processes in many companies in which all of these things have been done, to the amazement and gratification of the managers involved.

Management Must Be Sold

The failure to apply the techniques certainly has not been due to any desire on the part of managers to perpetuate scrap losses, inspection costs, and customer complaints. The managers quite obviously want to improve their performance in these respects. Granted, there is some indifference among those managers who are drugged by favorable profit statements and who are not driven by economic necessity to spend time on how to improve operations. But in the main, managerial attitude toward the objectives of quality control is one of longstanding agreement.

To many quality-control engineers, the inability to "sell" the shop executive is the main cause of frustration. From the viewpoint of the quality-control engineers, here is a proved set of techniques whose logic is unassailable; therefore anyone who does not accept the logic is an obstructionist and should be commanded to comply. This is all very well, but it ignores the views, the responsibilities, and the rights of the executive.

Sound organization practice requires that if the shop executive is to be held responsible for conduct of shop affairs, he must be given coextensive authority to regulate those affairs. If the top management adheres to this sound organization practice, it will not tell the shop executive he must adopt certain techniques. To tell him he "must" do something

Michigan

WELDED STEEL TUBING

ROUND

¼" to 4" O. D. 9 to 22 gauge

SQUARE-RECTANGULAR

½" to 2" 20 gauge 1" to 2¾", 14, 16, 18 gauge

Can be Bent,

FLANGED, EXPANDED, TAPERED, DEPRESS BEADED, EXPAND BEADED, ROLLED, EXTERNAL UPSET, INTERNAL UPSET, SPUN CLOSED, FORGED, BEVEL FLANGED, FLATTENED, SWAGED, FLUTED.

Uniform

STRENGTH, WEIGHT, DUCTILITY, MACHINABILITY, WELDABILITY, I.D. and O.D.

Consult us for engineering and technical help in the selection of tubing best suited to your needs.

Thousands of products today—from the smallest "Gadget" to the largest—earn more profits because of the use of MICHIGAN WELDED STEEL TUBING. The quality and dependability of MICHIGAN TUBING make possible similar profits for manufacturers who have not as yet considered the design and fabrication advantages of welded steel tubing.

A Quality Product, can be worked in your plant or prefabricated by MICHIGAN.

Michigan STEEL TUBE PRODUCTS CO.

33 Years in the Business

9450 BUFFALO STREET • DETROIT 12, MICHIGAN

FACTORIES: DETROIT, MICHIGAN • SHELBY, OHIO

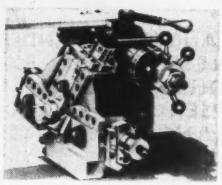
DISTRIBUTORS: Steel Sales Corp., Detroit, Chicago, St. Louis, Milwaukee, Indianapolis and Minneapolis—Miller Steel Co., Inc., Hillside, N. J.—C. L. Hyland, Dayton, Ohio—Dirks & Company, Portland, Oregon—James J. Shannon, Milton, Mass.—Service Steel Co., Los Angeles, Calif.—American Tubular & Steel Products Co., Pittsburgh, Pa.—Strong, Carlisle & Hammond Co., Cleveland, Ohio

To make a product as nearly perfect as fastenings can make it . . .

The only place to use a cheap screw is when you don't care if it holds or not. Usually shearing or loosening costs thousands of times what you "save" on the cheapest fasteners.

You pay no premium for *genuine* Allen Head screws—only enough to *assure* uniform strength and Class 3 fit.

Allen gives you the toughness of Allenoy steels, 100% Pressur-forming, the advantage of every proved threading method, quality control at every step, including automatic instrument controlled atmosphere heat treating.



This leading machine tool manufacturer uses Allen Head screws by the hundreds of thousands for compact design, assured holding power and maintenance of precision adjustments.

SOLD ONLY THROUGH LEADING DISTRIBUTORS

Write the factory direct for technical information and descriptive literature.

WARNING
Allen-Type screws aren't necessarily Allen-Made.
Get genuine Pressur-Formed Allen Head screws in this black and silver box.

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MANUFACTURING COMPANY

Hartford 2, Connecticut, U. S. A.

NEW YORK, CLEVELAND, DETROIT CHICAGO, LOS ANGELES

is to relieve him of the responsibility for any failures which might be assigned by him, rightly or wrongly, to these techniques. The top management can only ask that the shop executive give consideration to these techniques. From there on, the quality-control engineer is on his own. He must sell his service by demonstration, by persuasion, by patience, and by all other known devices of salesmanship, including of course the excellence of his service.

To most engineers or scientists, selling seems to be an unnecessary, distasteful, and degrading chore. That they think so is an indictment of their technical training quite as much as an indictment of their lack of experience in human relations. Actually, there is no escape from the need to sell, nor should there be. If the quality-control engineer cannot convince the shop executive through the democratic process of free choice the matter should end there. Progress achieved through dictatorial methods is achieved at too high a price in human relations. *From a paper by J. M. Juran, chairman, department of administrative engineering, New York University, presented at the ASME Annual Meeting in New York.*

Don't Forget Machine Guards

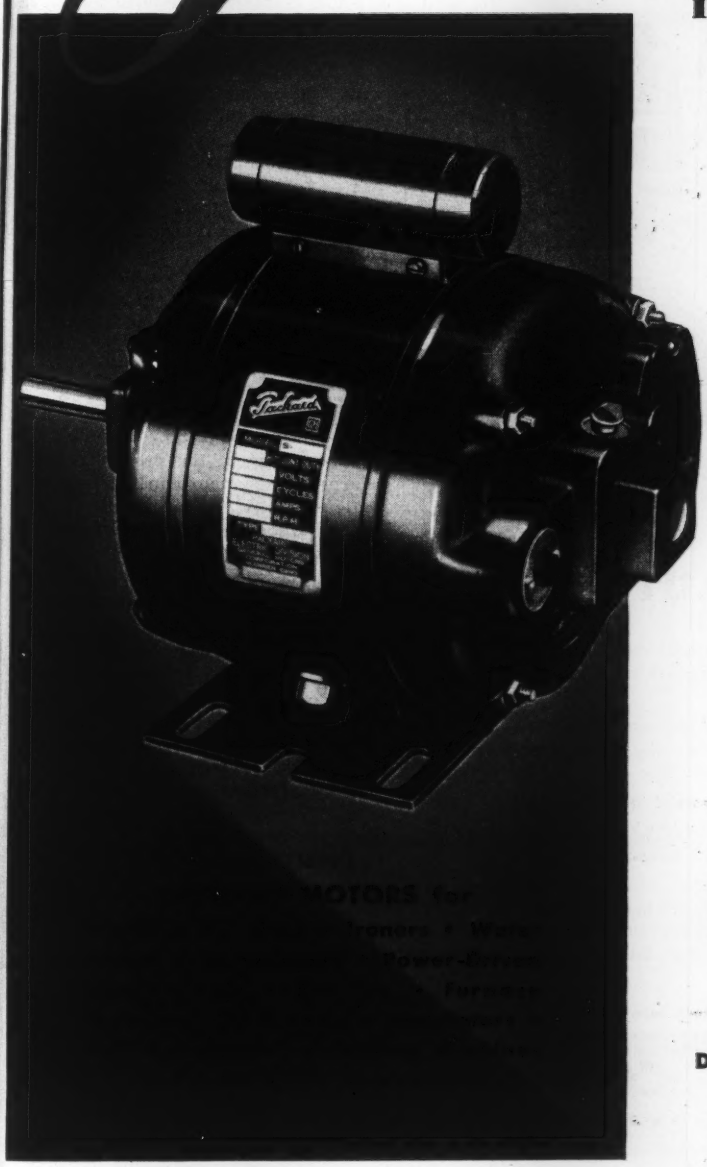
THE objective in machine guarding is to stop personal suffering and to minimize the probability of interrupted production because of accidents. It is true that very few accidents occur because of mechanical defects of a machine but, so long as human nature is what it is, we cannot rely upon instructions to avoid hazards that can be eliminated by mechanical guarding.

It is readily admitted that if a machine is always operated in a certain designated manner and the operator follows certain controlled movements there should be no need for safeguards. But nationwide records show that approximately 85 per cent of our industrial accidents involve the failure of individuals to observe the right way of doing a job.

We must recognize the fact that it is not sufficient to design a machine that mechanically will perform the operation for which it was designed and disregard the effect that the operator may have on its production efficiency. The mechanical efficiency of a machine may be very high but unless that machine can be operated by the average worker without interruption due to accidents, its overall efficiency from a commercial point of view will be relatively low.

Guards must be considered an in-

Perfect for [illegible] purpose...



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Packard motors are mass-produced by specialists who have built fractional horsepower motors *exclusively* for the past 33 years. Today our enlarged plant facilities and all of our engineering and manufacturing experience continue to be concentrated in this single field.

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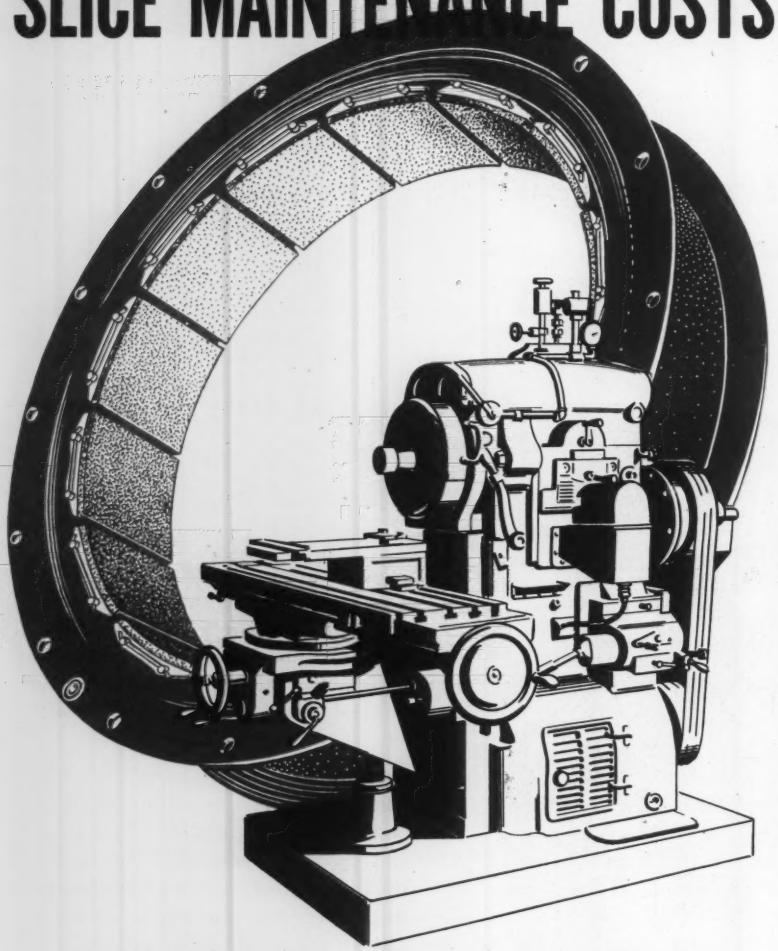

WITH FAWICK CLUTCHES

Improved clutch operation and lower maintenance costs become standard when machines are equipped with Fawick Airflex Clutch and Brake Units.

The full force of the clutch or brake action is exerted over the 360° friction surface of the drum—the most effective operating area.

Increased machine production is obtained by precision starts and stops. Maintenance is lowered by the reduction of down-time for lubrication or adjustment caused by wear.

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All desirable clutch characteristics are built into Fawick Airflex units

FAWICK Airflex CO., INC.

tegral part of the machine and not something separate and apart from it. A machine's value is proportional to its net output and if, because of inadequate safeguards, the output is lowered then the machine was improperly designed. Machines require operators to make them useful and the attitudes, characteristics, emotions or weaknesses of these people cannot be overlooked.

There are a few general items that may be helpful to the guard designer based upon the criticisms of existing devices:

1. The guard should be designed and not just built with whatever material happens to be available. Too frequently a device is a guard in appearance only. The framework is weak and the fastenings inadequate. If the guard is subject to motion, all bearing points should have sufficient surface to eliminate lost motion and permit of maintaining adjustment.

2. The guard should be constructed with the same degree of precision as the rest of the machine. It should blend in with it and not appear to be a contraption that is obvious to anyone as being an afterthought. Guards can be made attractive so that the operator does not want to remove them.

3. Wherever it is possible the guard should be interlocked in some manner so that the machine cannot be normally operated without the guard being in place.

4. The installation of the guard should not introduce additional hazards to the operation. Some of the common ones in the past have been sharp edges, pinch points, eye strain, difficulty in oiling or adjusting and a fire hazard because its construction collected lint and dust.

It is hard to believe that, since industry became guard conscious about 35 years ago, no real change has been made, that would indicate that safeguarding of machines has been considered in basic design. *From a paper by R. J. Crosley, mgr., safety engineering department, Marsh & McLennan, presented at the ASME Annual Meeting in New York.*

Determining Surface Finish With Plastics

IMPRESSIONS of surfaces to produce negative replicas of finishes and wear patterns have been employed for many years. Materials for this use include plaster of Paris, wax, low melting point alloys, sulphur-graphite mixture, and resins including both thermosetting and thermoplastic. These means produce three dimensional records. They may be

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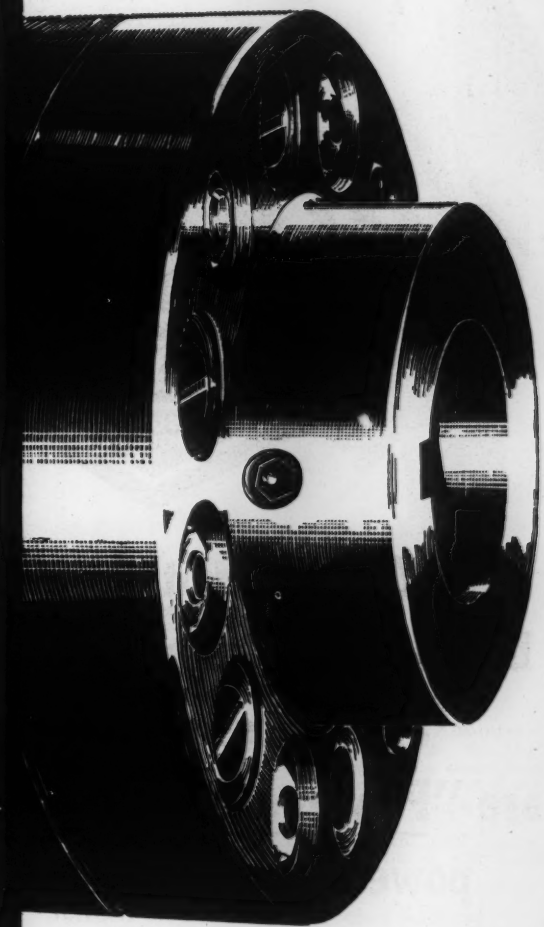
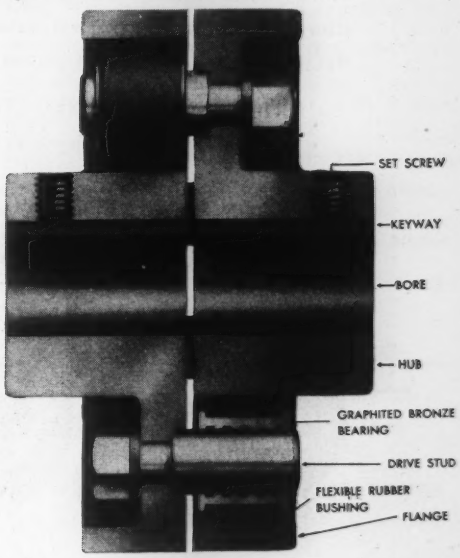
The positive, resilient drive provided by Ajax Flexible Couplings has proved to be good economy for manufacturers of good machinery over a period of 30 years. Ajax Rubber Bushed Flexible Couplings permit each shaft to rotate around its own axis without creating vibration, backlash, shocks, strain on bearings, power loss, reversal of torque or other detrimental factors entering into the direct connection of power.

The cross-section view shows how Ajax Rubber Bushed Bronze Bearings and hardened and ground steel studs provide flexible yet positive drive.

Standard Ajax Couplings are made of forged steel or cast steel. Aluminum, bronze and other metals available for special applications. Made in a wide range of sizes and capacities.





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grouped as pressure applied films and castings. The applied film technique includes: (1) Molding a thermoplastic resin on the surface under study by the application of external heat and pressure, and (2) softening the surface of a plastic by action of a solvent and then molding the film on the surface by application of pressure. The applied film accurately records surface finishes and permits ready means for magnification. However, these methods are not well suited for irregular surfaces or for inaccessible areas.

A new method developed by the Bureau of Ships for recording surface finish and wear patterns utilizes a free flowing polyester resin. This resin hardens in ten to twenty minutes, after the addition of a catalyst, without application of external heat or pressure. The impression is formed by casting the resin-catalyst mixture on the surface to be recorded. The casting may be removed for study.

The procedure for producing a plastice negative replica of a metal surface is simple. Use of elaborate equipment and strict adherence to minute details are not required. There are, however, simple routine steps that should be followed to give the most accurate reproductions. It is essential that the metal surfaces be free of foreign materials such as oil, grease, scale, water and other matter that would result in poor reproductions or sticking of the resin.

There are many advantages of this method of recording surface finish and wear patterns over those employed in the past. The most significant of these include the following:

1. Accuracy of the negative reproduction is well within that of measuring instruments
2. The impression is durable and its surface may be tested with a Profilometer or Brush analyzer
3. Equipment required to use the resin consists of scotch tape and a stirring rod
4. External heat and pressure are not required
5. Time for producing a negative may not exceed 45 minutes
6. Inexperienced personnel can produce good results with very little instruction
7. Relatively inaccessible areas can be recorded and studied.

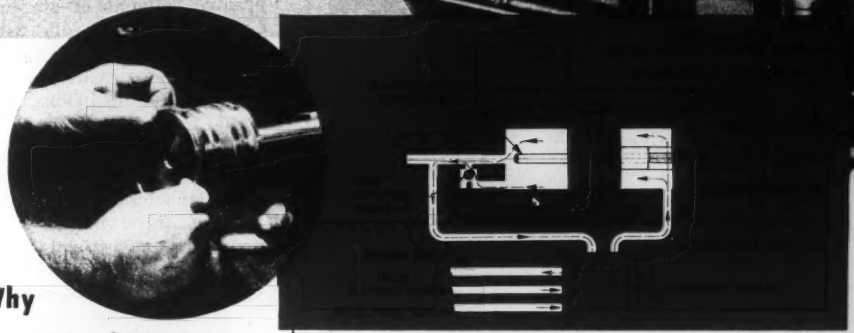
Experience with this method has shown it to be entirely satisfactory for use in indicating general wear patterns and recording surface finishes with extreme accuracy. *From a paper by John W. Sawyer, Bureau of Ships, Navy Department, at Society of the Plastics Industry Inc. Plastics Seminar in Washington, D. C.*

HOW THE HYDRAULIC SYSTEM OF AN AUTOMATIC LATHE

IS DESIGNED FOR *Smooth Performance*

WITH

BURD "Graf-Flox" PISTON RINGS



Gisholt No. 12 Automatic Lathe has 3 hydraulic cylinders — (1) for longitudinal feed, front slide; (2) in-feed, rear slide; (3) in-feed, front slide.

Why BURD "Graf-Flox" Rings Offer Profitable Advantages

- Made from fine-grain electric furnace iron, metallurgically controlled—assures best lubricating and wearing qualities.
- Tension cast-in by individual molding method insures long life under extreme operating conditions.
- Precision machined to close tolerances —insures easy accurate fitting, maximum heat dissipation.
- "*Graf-Flox*" finish—removes "smear" layer from machining operations—provides faster, better break-in surface, eliminates scuffing or seizing.
- Wide range of types and sizes especially engineered and machined to suit your needs.

4-Ring Piston Accurately Controls Variable Feed Rates

A simplified hydraulic system on the popular Gisholt No. 12 Automatic Lathe provides complete uniformity and stability of carriage motion. Hydraulic line pressure only is utilized to effect changes in the operating cycle. Pressure variations from 60 to 800 psi are efficiently controlled by 4-ring pistons equipped with Burd "Graf-Flox" compression rings. Two pistons have 4-3½ x 3/16" rings and one has 4-4½ x 3/16" rings. Cylinders are honed to ±.0005" of nominal size. Pistons are ground .002" under cylinder size. Ring grooves are cut to allow a depth clearance of .026" and a side clearance of .0015".

No Run-in Required—Surface Treatment Eliminates Seizing

The rings are precision machined and are fitted to the cylinders with a gap clearance of .002" to .003". All rings are treated (Burd's exclusive "Graf-Flox" Process), to provide a superior bearing surface. Frictional resistance upon installation is reduced as much as 60%. *No run-in is required, and scuffing and seizing is eliminated.* Natural graphite, inherent in the ring metal, is exposed to the outer surface. The "smear" layer resulting from machining operations is entirely removed. Cast-in tension and close metallurgical control assures long wearing qualities after seating. Results show smooth, dependable performance is obtained by Gisholt, a Burd user for over 15 years.

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Call on Burd engineers for help with your ring design problems. No obligation. Write today for free specification sheets and more facts.

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Automotive and Industrial

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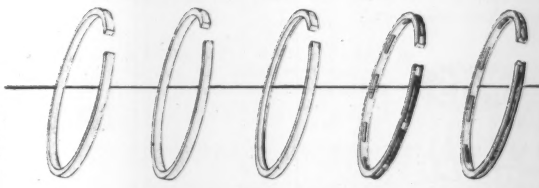

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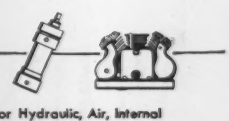
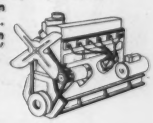
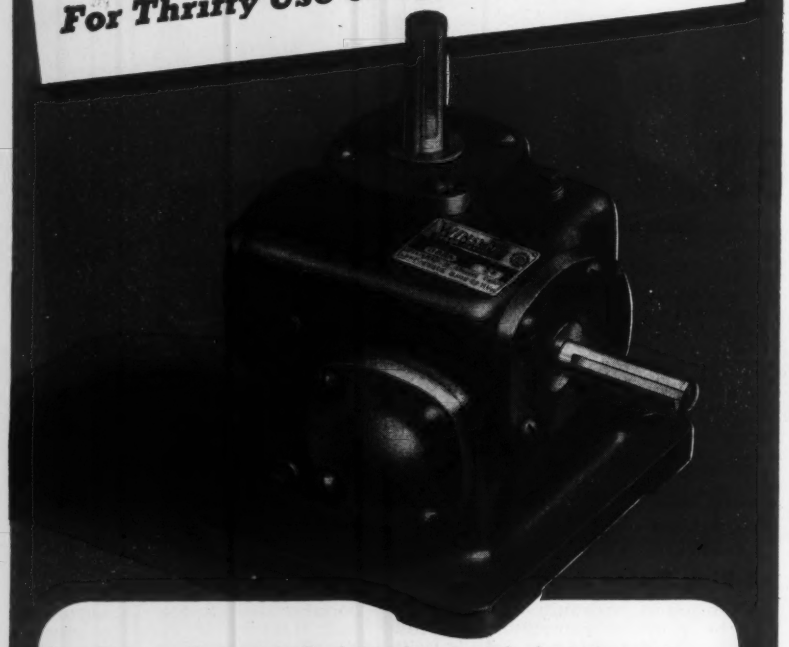


For Hydraulic, Air, Internal Combustion Engines . . . Sizes From 7/8" to 16" Diameter



NEW SPEED REDUCTION PACKAGE

For Thrifty Use of Space and Power



From a reducer originally designed to serve the low power, confined area requirements of moving merchandise displays weighing up to 1500 lbs., the new Winsmith Type DBRA now shapes up as one of the most versatile designs ever created for *any* duties involving transmission of small power loads.

For the countless applications calling for use of 1/20 to 1/8 horsepower, designers and users were formerly obliged to sacrifice space, weight and money by specifying large, expensive speed reducers with power ratings of 50 or 100 times that required of them.

In your plant, or on the products you make to sell, there are perhaps many instances where the unique features of this newest addition to the Winsmith line can be applied, to your immediate and continuing profit. For here is the lightweight speed reduction package that is engineered to fit . . . the only such vertical, worm gear type that offers the power rating you want in 23 different shaft locations and in reduction ratios of 25:1 to 1764:1.

But DBRA may not be the only type required for improving the productivity of your equipment or the salability of your products. If that's the case, virtually any speed reducer your needs may dictate can be selected from Winsmith, the world's most complete line. Without obligation to you, a Winsmith transmission engineer will not only aid you in your selection, but will review your present or projected power transmission systems to help create for you the kind of success story told of so many Winsmith users — verified stories that feature the achievement of better service, lower cost and higher sales. Write . . . ask, without obligation.

★ DESCRIPTIVE LITERATURE on new type DBRA, as well as Catalog-Handbook *free on request.*

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NEW MACHINES

And the Companies Behind Them

Business Equipment

BILLING MACHINE. Composite Model D machine with 18 or 24-in. carriage. For department stores or other retail organizations. Features automatic inactive column skip to omit purchases, payments and return columns on history ledger cards when there are no postings in comparable columns of statement. Includes posting media table, new dial indicator on adjustable ledger stop, snap-on carriage engaging and disengaging blocks, and larger front feed lateral guide. Underwood Corp., New York, N. Y.

PRINTING MACHINE. Hand-operated offset machine for printing illustrations, trade marks, trade names or other advertising matter on pens, pencils, lighters, etc. Uses type, cuts or electros to print area up to 3 by 4½ in. on most surfaces. Production rate, 500-800 pieces per hour. Machine prints by transfer process. Apex Machine Manufacturing Corp., New York, N. Y.

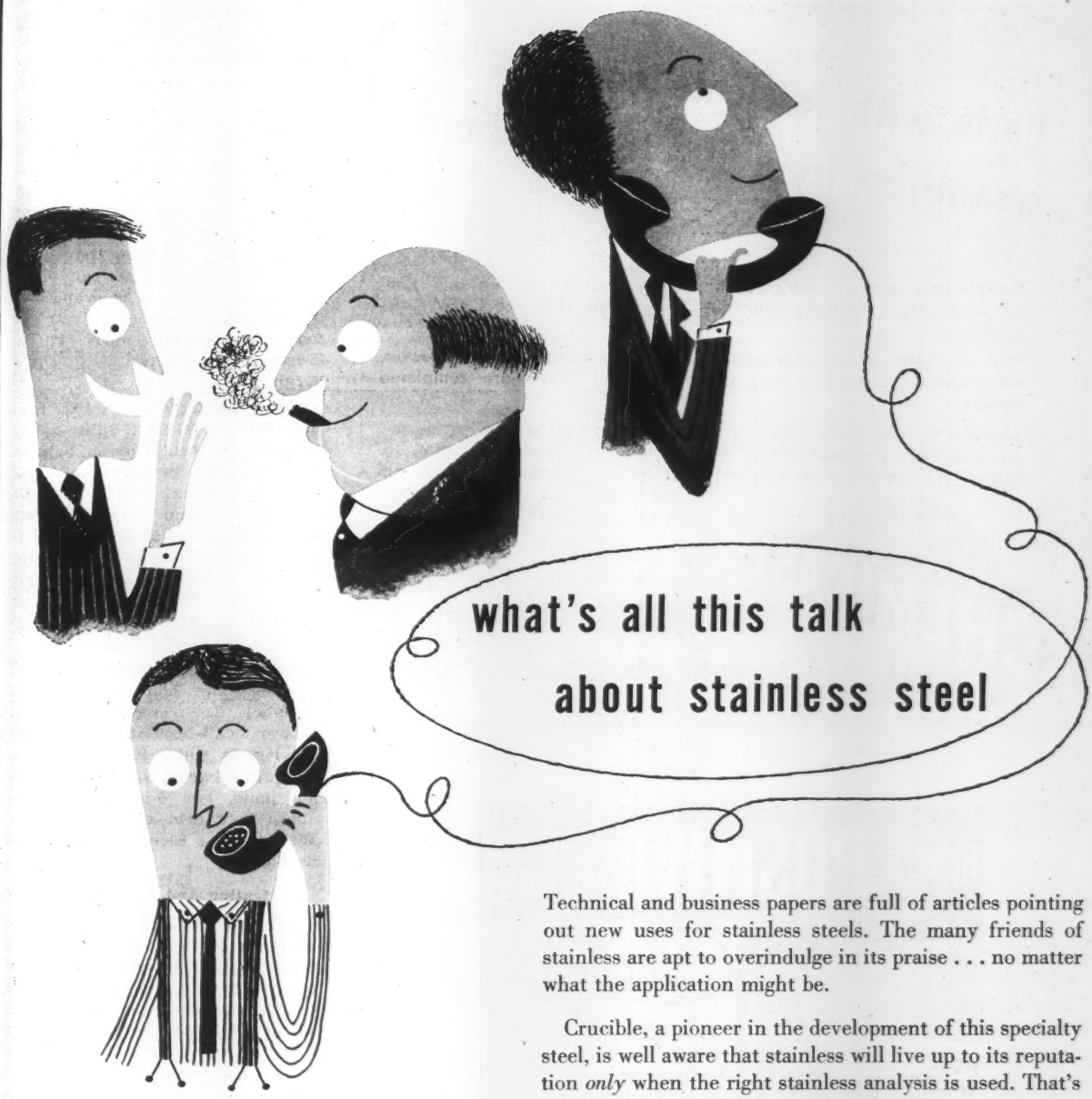
Commercial

WATER HEATER. Provides sterilizing water for small restaurants. Input capacity, 40,000 Btu per hour. Stores 4½ gal water at 180 F for rinsing operation. Unit takes water from regular warm water supply. Outside dimensions—30 in. high and 16 in. in diameter—permit installation under counter or in other confined area. A. O. Smith Corp., Toledo, O.

REFRIGERATORS. Glass door reach-in models for food and dairy stores, restaurants, hotels, etc. Capacities; 27, 44 and 62 cu ft. Constructed of heavy gage steel with welded overlap joints and interiors finished in white porcelain. Include 3 in. fibrous glass insulation, automatic interior lights. Frigidaire Div., GMC, Dayton, O.

Domestic

AUTOMATIC WASHER. Rectangular, top-loading model does not require bolting down. Normal capacity, 9 lb; when 5 lb or less are to be washed, water required can be reduced 40% by adjusting water control valve. Overflow rinse removes loose soap and curd. Washer automatically soaks, washes, rinses,



Technical and business papers are full of articles pointing out new uses for stainless steels. The many friends of stainless are apt to overindulge in its praise . . . no matter what the application might be.

Crucible, a pioneer in the development of this specialty steel, is well aware that stainless will live up to its reputation *only* when the right stainless analysis is used. That's why Crucible offers the services of a staff of metallurgists to help you apply stainless to your application.

These engineers and metallurgists are freely available to you. One word from you puts a background of fifty years of specialty steel leadership at your service. CRUCIBLE STEEL COMPANY OF AMERICA, Chrysler Building, New York 17, N. Y.

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Cross-section of An-cor-lox cap bolt showing locking ring after flattening.

Not necessary for bolt to come through nut. Locking ring on bottom of nut.

Thread fit NOT important.

Vibration and shock will not walk nut off—will only force locking ring farther into bolt threads.

Bolt stretch, wear, moisture do not affect gripping power.

Up to softening point of the metal, high temperatures do not lessen locking grip.

Crushed locking ring prevents passage of gas and liquids.

Nut can be re-used many times.

Available in high, thin, cap or spanner designs.

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LAMINATED SHIM CO., Inc., *An-cor-lox Division*, 1203 Union St., Glenbrook, Conn.

AN-COR-LOX NUTS • SHIMS • SHIM STOCK • STAMPINGS

damp dries and shuts down. General Electric Co., Bridgeport, Conn.

REFRIGERATOR. Capacity, 9.6 cu ft. Automatic rapid defrost system uses electric heater to warm Freon which is circulated through system to melt frost from freezer walls. Defrost cycle automatically operates after door has been opened 60 times, or about once a day. Defrost time varies from 3 to 25 minutes, frozen foods will not thaw. Defrost water drained to pan under compressor where it is evaporated by heat from compressor. Frozen food compartment holds 41 lb. Westinghouse Electric Corp., Pittsburgh, Pa.

ELECTRIC RANGES. Width, 30 in. Feature full-width oven with sliding shelves adjustable to 5 heights. Units finished in porcelain inside and out. Delux model available with timer, lamp and clock. Both models have 4 standard-size, 5-speed cooking units—three 6-in. diameter units, and one 8-in. unit. Full width utensil drawer under oven carried on Nylon rollers. Frigidaire Div., GMC, Dayton, O.

ELECTRIC RANGE. Designed for small kitchens, unit has appearance of knee-hole desk. Oven and storage drawer located on left, chrome tubing leg on right. Range is 38 in. wide, has two 8-in. surface cooking units, two 6-in. units. Automatic oven heat control provided. Westinghouse Electric Corp., Pittsburgh, Pa.

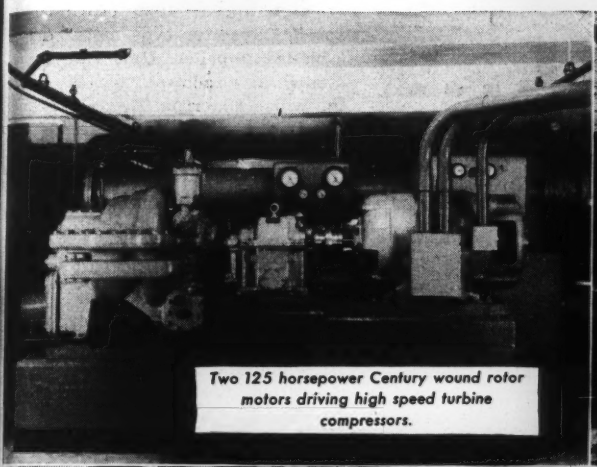
Heating and Ventilating

GAS CONVERSION BURNERS. Upshot burner head capable of burning all types of gas. Capacity range, 70,000 to 400,000 Btu depending on type of gas and size of valve and regulator. Equipped with completely automatic controls. Complete assembly comes out of air box by disconnecting one union. Harvey-Whipple Inc., Springfield, Mass.

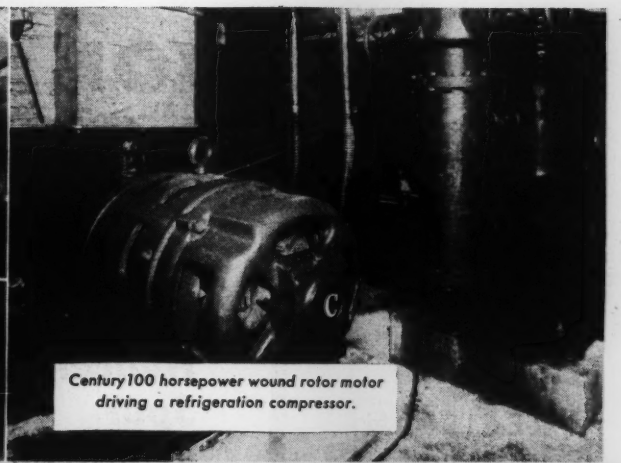
ROOM AIR CONDITIONER. One-hp window units powered by 2 Meter-Miser refrigerating systems. Adjustable louvers in grill direct air to any part of room. Filter easily removed from bottom, air drawn through bottom rather than sides. Frigidaire Div., GMC, Dayton, O.

WINDOW FAN. Two-speed, 16-in. window fan delivers 2000 cfm on high speed. Mounting panels adjustable for windows 27½ to 36 in. wide. Units finished in ivory, use 4-bladed fan protected by expanded metal grille. Emerson Electric Manufacturing Co., St. Louis, Mo.

WINDOW FAN. Two-speed fan uses 20-in. blade. Capacity, 35,000 cfm



Two 125 horsepower Century wound rotor motors driving high speed turbine compressors.



Century 100 horsepower wound rotor motor driving a refrigeration compressor.

Century 75 and 30 horsepower wound rotor motors driving a bending roll.

Century wound rotor motor.

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Meet Load Characteristics for:

1. Adjustable varying speeds control variable process and other load conditions.
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3. Syncro-speed, multiple drives used where two or more operations must be coordinated.
4. High starting torque with low starting current — such as reciprocating compressors, steel plate bending rolls, etc.

Century wound rotor motors are built in sizes up to 400 horsepower and are available in open protected and splash proof frames. In addition, Century builds a complete line of AC and DC motors in sizes from 1/6 to 400 horsepower for all popular requirements.

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Split Phase Induction— 1/6, 1/4, 1/3 H.P.
Capacitor— 1/6 to 20 H.P.
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DIRECT CURRENT MOTORS
1/6 to 300 H.P.

GENERATORS
AC, .63 to 250 KVA
DC, .75 to 200 KW

MOTOR GENERATOR SETS
AC to DC, AC to AC
DC to DC, DC to AC

Open Protected, Splash Proof, Totally Enclosed Fan Cooled, Explosion Proof.

Ball Bearing motors are factory lubricated for several years' normal service. Bearing housing construction permits easy re-lubrication when unusual service demands it.

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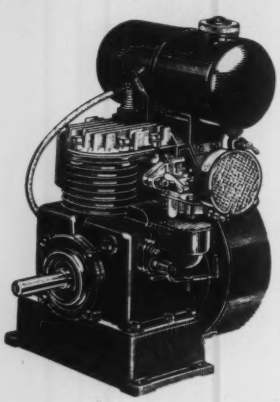

Model K7-1, *1½ H.P. 4-cycle, single cylinder, air-cooled. Length 13", width 14", height 17", Weight 38 lbs.*

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at high speed; 1925 cfm at low speed. Capacitor type motor drives 3-bladed impeller. Unit can be installed in windows from 20 to 36 in. wide. Emerson Electric Manufacturing Co., St. Louis, Mo.

Heat Treating

REGULATING AND HEATING UNITS. For preheating before welding and stress relieving after welding. Combination includes 40 kva Model RTA regulating unit and 40 kva Model AC3 low frequency induction heating unit. Regulating unit arranged for 220, 440 and 550-volt operation. Electric Arc Inc., Newark, N. J.

Maintenance

EXTENSION SPRAY GUN. Capable of reaching to second-story level. Available in lengths from 4 to 12 ft in 2-ft increments. Weight of 6-ft extension, 4 lb. Series of guns can spray any fluid from light paints to heavy asphaltic compounds. Eclipse Air Brush Co., Newark, N. J.

Manufacturing

VERTICAL MILLING MACHINE. Adjustable swivel head turns through 180 degrees for milling, drilling, boring or routing. Machine holds tolerances to 0.001-in. Spindle mounted on tapered roller bearings. Columbia Enterprises Inc., Grayslake, Ill.

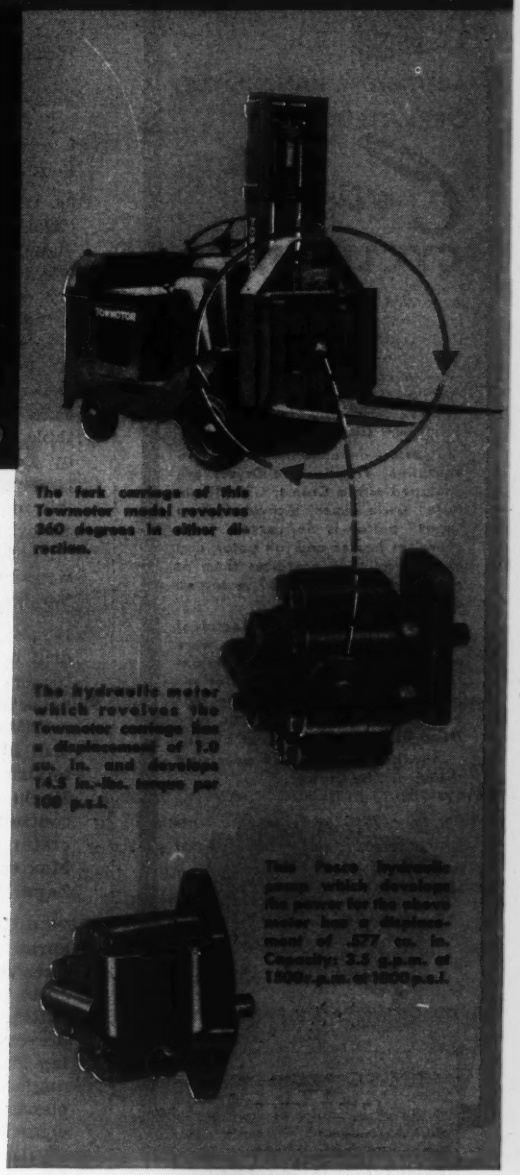
FOOT PRESS. Features 4-ft throat depth. Capacity, 2-in. hole through 16-gage mild steel or the equivalent. Punch operated by pedal through lever and toggle linkage that multiplies foot pressure. Frame welded from heavy sheet steel; stand fabricated from angle iron. Whitney Metal Tool Co., Rockford, Ill.

SHEAR. Capacity, 12 ft of 1-in. steel plate. Uses pivoted blade cutting principle. Upper blade operates on two heavy pins secured to side frames and travels in circular path. Knife adjustment made by turning crank and watching dial indicator showing clearance in thousandths. Shear cuts at 25 strokes per minute. Throat depth is standard for all Steelweld shears, 24 in. Bed has ball-bearing transfers to facilitate movement of steel through knives. Machine uses electric foot switch control. Cleveland Crane & Engineering Co., Wickliffe, O.

FORM CUTTER. For cutting internal spur gears, splines and most other shapes that lend themselves to form cutting with radially-fed tools. Machine handles minimum ID of 5.4 in.; max ID of 20 in. Machine cuts 5000 gears of 12-in. pitch diameter

Another Job for Pesco HYDRAULIC MUSCLES

DUMPING MULTI-TON LOADS IN 5 SECONDS


The fork carriage of this Towmotor model revolves 360 degrees in either direction.
The hydraulic motor which revolves the Towmotor carriage has a displacement of 1.0 cu. in. and develops 14.5 in.-lbs. torque per 100 p.s.i.
This Pesco hydraulic pump which develops the power for the above motor has a displacement of .577 cu. in. Capacity: 2.5 g.p.m. at 1800 r.p.m. at 1000 p.s.i.

● One of industry's most effective material handling time-savers is Towmotor's fork lift truck with the revolving carriage. With it a man can quickly and easily transfer heavy loads of solid, liquid, or granular material from one container to another.

The ingenious device that revolves the fork carriage in a 360-degree circle, in either direction, is actuated by a Pesco hydraulic motor so small it will fit snugly into the palm of your hand. Yet it is so powerful it will flip loads up to three tons completely over in five seconds!

Towmotor is one of the rapidly growing number of industrial equipment manufacturers who are turning to Pesco for answers to their hydraulic problems. They have found that the skills and precision craftsmanship that Pesco has developed to meet the exacting requirements of the military and civilian aircraft manufacturers insure the high quality and trouble-free operation they demand in their own products.

Perhaps the sales power of hydraulic power can help you, too. If you have a problem in squeezing, gripping, lifting, holding, or turning heavy loads with precise accuracy and finger-tip control, why not let Pesco engineers suggest a solution.

A preliminary discussion will involve no obligation.

engineering Pesco production

PRODUCTS DIVISION

BORG-WARNER CORPORATION

24700 NORTH MILES ROAD BEDFORD, OHIO

without requiring tool regrind. Machine cycle time on this job, 24 sec; hourly production, 85-90 parts. Michigan Tool Co., Detroit, Mich.

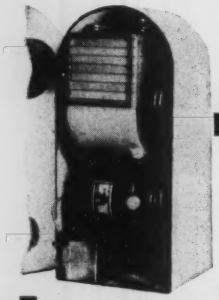
DRILLING MACHINE. Medium-weight machine with 25-in. swing. Powered by 1½-hp axial air gap type motor. Rated capacity of machine in steel, ¾-in.; in cast iron, 1 in. Five spindle speed ranges available, each with 4 to 1 ratio: 206-825 rpm to 540-2160 rpm. Tachometer on front of drill gives spindle speed. Table measuring 18 by 26 in. is accurate to 0.0007-in. in 6 in. Sibley Machine & Foundry Corp., South Bend, Ind.

TOOL GRINDER. Bench type, universal carbide tool grinder for use with diamond wheels. Can be used as surface grinder, chip breaker grinder, or universal tool and cutter grinder. Both table and motor swivel; motor and wheel can be set 20 degrees either side of vertical. Levers and handwheels provide vertical, longitudinal and transverse table movement. Coolant supplied by 12 gph centrifugal pump. Unit powered by 2850-rpm, 1-hp reversible motor. Grinding wheels mounted on 1¼-in. ball bearing spindle on adapters to give spindle extensions of 2⅛ and 5⅜ in. Wickman Manufacturing Co., Detroit, Mich.

HORIZONTAL DRILL. Uses two gearless drill heads and two hydraulic drill feeders to drill and countersink holes on both sides of ⅜-in. square extruded bar stock. Drill heads drill 20 holes at first station, countersink 20 holes at second station. Machine entirely automatic, speed controlled by time required for operator to index and position stock. Max capacity, 3600 holes per hour. Zagar Tool Inc., Cleveland, O.

BENCH GRINDER ATTACHMENT. For accurate grinding of carbide tools. Uses reciprocating action tool holder to produce straight and smooth cutting edge. Continuous motion prevents overheating of carbide during grinding. All front, side and top angles set in vertical and horizontal planes. Feed of tool toward wheel controlled by feed knobs graduated in 0.001-in. divisions. Tool holder takes cutting tools to 1¼ in. high, swivels to permit grinding right or left-hand tools. E. F. Hager and Son, Queens Village, N. Y.

HANDLEVER BED TURRET. For use with 9, 10 and 13-in. swing South Bend lathes. Turret mounts on inside bed ways, turret base can be locked at any point along bed. Effective feed of turret slide, 4 in.; distance from center of turret head to top of slide, 1½ in.; distance across tur-



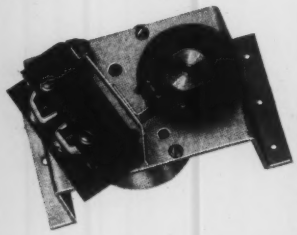
AUTOMATIC HAND DRYER
OPERATED BY
Cramer
CYCLE TIMER

A product of Electric-Aire Engineering Corp., the Electric-Aire Hand Dryer provides completely automatic and uninterrupted hand drying service in schools, theatres, offices, hospitals, factories, etc. Dries hands quickly, thoroughly . . . helps keep washrooms cleaner.

To assure dependable, trouble-free operation, Electric-Aire Dryers are equipped with a Cramer CF5 (Single Pole) Cycle Timer. Activated when "start" button is depressed, timer energizes heater and fan motor, and automatically de-energizes them at end of predetermined 37½ second drying period.

"Gruelling tests of all electrical and mechanical components were made under the close and constant supervision of our own corps of engineers before their use in the regular production of Electric-Aire Hand Dryers."

Another example of precision timing . . . by Cramer.



TIMING PROBLEM ?

If the performance of your product depends on precision timing, send us full particulars about your application. In developing a range of devices — Time Delay Relays, Interval Timers, Percentage Timers, Running Time Meters, Synchronous Motors — for a great variety of commercial and industrial timing duties, we have had wide experience in the design of equipment to meet many specific needs . . . and will welcome the opportunity to assist in solving your problem.

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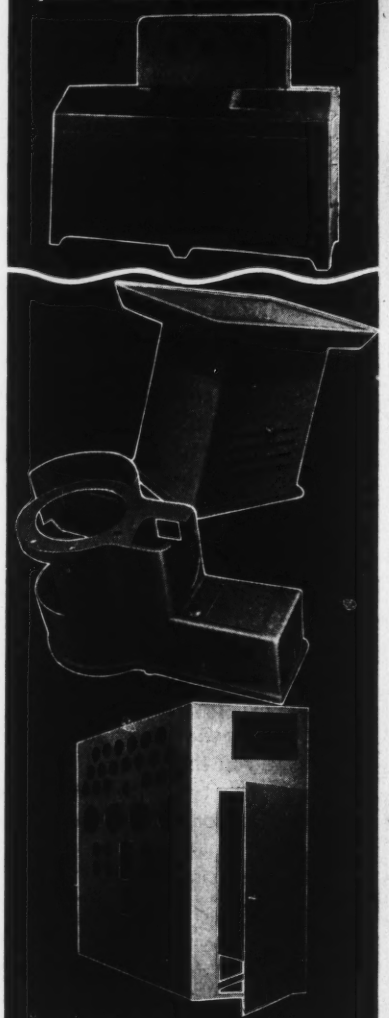
WELDMENTS
for High
Quality Products

When designing new products remember Littleford can fabricate plain or alloy plate and sheet metal into any size or shape Weldment to fit your needs. Littleford Weldments for 68 years have played a vital part in many a product, such units as Bases, Guards, Pans, Louver Covers, or Special Parts have been produced at low cost by precision work and know how. Experience in bending, forming, shearing and welding is assurance of the high quality Weldments. Send blue prints to Littleford for estimates.



FABRICATORS OF PLATE AND SHEET METALS

LITTLEFORD

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424 E. Pearl Street, Cincinnati 2, Ohio

Powerful New Source of Sonic Energy

Ultrasonic Corp. Model U-4 Sonic Generator

Over 300 watts of acoustic energy — at an intensity level of 165 decibels — produced by this EEMCO-powered sonic generator

A Special EEMCO Motor for a Special Duty

This is the most powerful gas phase source of sonic energy commercially available. Only 28 inches overall, and extremely simple and compact, this sonic generator produces over 300 watts of acoustic power. This equipment was developed by *Ultrasonic Corp.*, Cambridge, Mass., for use in industry and research. Dust and mist collection, destruction of bacteria, and increasing seed germination are a few of many interesting applications.

EEMCO engineers developed the special motor application for this unit, meeting severe demands of compactness, operational simplicity, and flexibility. The 1½ hp *EEMCO* universal type, explosion-proof motor operates at the wide speed range of 5400 to 18,000 rpm (with Variac speed control). Extremely close concentricity of the special mounting adaptor with the output shaft was required . . . and was achieved with a tolerance of 1/1000 inch.

Design ingenuity and production skill . . . this is the gratifying combination you get in *EEMCO* services. Let us consult with you on your current motor problems.

One of many powering problems solved by EEMCO

We have solved the widely varying electric drive problems of manufacturers of ultrasonic sound generators, oil well recovery tools, power saws, radar equipment, submersible pumping units, dairy homogenizers, ultracentrifuges, and aircraft. Our specialty is tough problems of function, power, size, weight, shape, performance, installation, and operation.

EEMCO

ELECTRICAL ENGINEERING and MANUFACTURING Corp.

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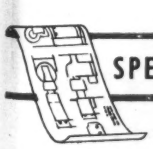
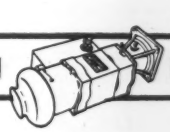
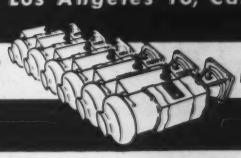


SPECIAL MOTOR DESIGN  **DEVELOPMENT**  **MANUFACTURING**

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This farm tractor throttle was designed to take advantage of the excellent frictional properties of sintered steel and bronze. Cost is very low, too.

V-belt driven centrifugal clutch assembly features low manufacturing cost and unequalled frictional properties.

Ratchet for automatic door closer, formerly cast and machined, now made of sintered iron at a saving of 50%.

For lower fabrication costs and improved performance—check powder metallurgy. Send your blueprints and production requirements to . . .

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ret head, 4⅞ in.; head bored to take six ⅝ or ¾-in. shank turret tools. Head will index to within plus or minus 0.0005-in. measured 4 in. from turret face. Crank type binder lever provided for locking head, head may be back indexed or spun to skip tool positions. South Bend Lathe Works, South Bend, Ind.

AUTOMATIC TURNING ATTACHMENT. For turning of shafts or tubes on precision lathes or screw machines. Especially applicable to long, thin work requiring smooth finish with tolerances to tenths. Attachment can also be used to center, drill, ream, tap, thread, thread chase and taper. The Todd Co., Rochester, N. Y.

PLASTICS MOLDING PRESS. Straight ram type hydraulic press. Capacity, 200 tons. For molding large parts having deep draws and heavy sections, such as radio cabinets, telephone bases, etc. Cycle operated by bar type controller, employs ram-within-a-ram for rapid closing. Automatic and adjustable slow close provided. Max hydraulic pressure, 2260 psi; max platen area, 26 by 25 in.; max opening between platens, 35 in.; max stroke, 15 in. Powered by 7½-hp motor. F. J. Stokes Machine Co., Philadelphia, Pa.

METAL DISINTEGRATOR. For removing broken taps and drills from holes without distorting threads, and for cutting shaped holes in dies. Operation consists of chucking unit in drill press, selecting proper size electrode and turning on. Includes self-feeding feature. Removes broken taps from 0.080 to 1-in. Operating cost, less than 5 cents per hour. Clinton Machine Co., Metalmaster Div., Clinton, Mich.

JIG DRILLER. Drill jig converted into drilling machine. Consists of 4-post pump type drill jig with attached gearless drill head having hole pattern to suit part being drilled. Feeding accomplished by operating handle which feeds parts into drills through standard rack and pinion mechanism. Drill head driven through V-belts. Coolant pump driven from reverse side of motor shaft. Zagar Tool Inc., Cleveland, O.

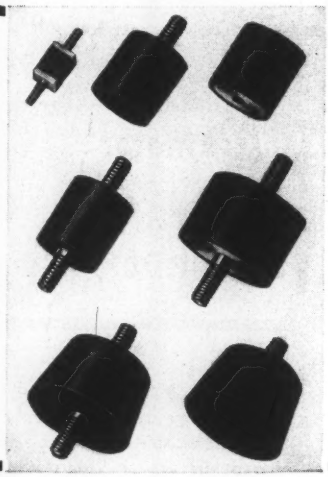
AUTOMATIC INJECTION MOLDER. Uses self-positioning lower mold section; half of mold is cleared and reloaded while other half is engaged in molding cycle. First applied to molding electric cord plugs with metal inserts. Hydraulically-operated rapid traverse bed carries lower mold section which is twice size of upper mold and contains duplicate set of cavities. Hydraulic action moves lower section into position after loading. Machine handles variety of thermoplastics in-

VIBRATION PROBLEM?

INVEST $2.00 SAVE $200.00!*

Protect Your Equipment With "FINNFLEX" Stud Type Vibration Isolators

***For an investment of $2.00 to $5.00 per machine, you can save HUNDREDS or even THOUSANDS of DOLLARS on your new equipment (case histories on file).**



"FINNFLEX" Stud Type Vibration Isolators have 54 load ranges of 1 lb. to 270 lbs. each. Rubber is bonded to metal, and has a breaking strength 15 times the working load. Isolator designs are essentially the same varying in dimension and rubber stiffness only. Cost is low! Write for prices!

Equipment which can use these Stud Type Isolators to reduce noise are: Small Motors, Fans, Blowers, Compressors, Generators, Pumps, Engines, Lathes, Grinders, Radios, Refrigerators, Gages, Scales, Switches, Panel Boards, Transformers, Air Conditioning and Ventilating Equipment, Neon, Fluorescent Lighting, Timing and other Sensitive Instruments.

In addition to stud type mounts, we have many other types of Vibration Mounts, to solve any type of vibration problem.

Write for Descriptive Literature!

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Westinghouse

Pumps and Compressors

Submerged in 6 ft. of Water..Open Motor Pumps Sump Dry

When water rose accidentally in a sump of an eastern plant, an open Life-Line motor was covered by six feet of water. Someone pressed the starter, and the Life-Line pumped the sump dry. Outside of being covered with a thick coating of mud and [illegible] motor [illegible]

Can your pumps use *MOTOR STAMINA* like this?

We certainly do not recommend open motors be operated under these conditions—in fact, we say DON'T DO IT! But this actual example illustrates the real stamina built into Life-Line motors—stamina resulting from improved materials and manufacturing methods.

Take the stator, for example. Coils are wound of Tufvar wire—wire you can pound with a sledge, tie into knots, without disturbing the insulation. Pear-shaped slots enable coils to be slipped into place without forcing. A fiber wedge closes top of slot, seals against dirt and moisture. Multiple dips and bakes in Thermoset varnish give the stator a tough flexible film, resistant to oil, moisture, acid and alkali. That's why, in the above example, there was no winding short-out—even under water.

It costs no more to get this extra motor stamina. Simply specify Life-Line as the drive for your equipment. Ask your local Westinghouse representative for details and a copy of booklet B-3842, or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.

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Westinghouse *Life-Line* Motors

INDUSTRY'S LEADING MOTOR

cluding nylon and vinyls. Mechanical toggle clamping lessens flashing. In 2, 3 and 4-oz capacities, with 20 to 40-sq in. casting areas. Moslo Machinery Co., Cleveland, O.

TILE CUTTER. For cutting and blocking floor materials. Production rates of 400 to 500 9-in. tile per hour possible. Clamping bar with self-adjusting shoes holds material for full length of machine bed. Machine handles roll or slab stock to 38 in. wide and ¼-in. thick. Cuts blocks from 4 to 24 in. in 1 in. increments. Power driven cutting head controlled by a foot pedal, leaving hands free to hold or guide stock. Falls Engineering and Machine Co., Cuyahoga Falls, O.

WET GRINDSTONES. Line includes floor model, 2-wheel unit and hand operated model. Self-adjusting friction drive provides constant peripheral speed of 280 fpm. Tool rest measures 2½ by 5 in., adjusts for grinding angles from zero to 30 degrees. Wheel, 1½ x 8 in. Boice-Crane Co., Toledo, O.

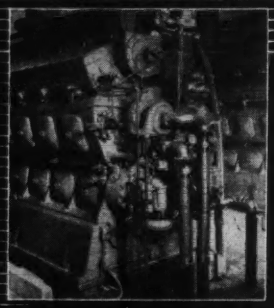
HAND LAPPING MACHINE. For finishing plane and cylindrical surfaces of small and medium size parts. Lapping plates measure 24 in. in diameter, either plain for cylindrical work or grooved for flat work. Plates made of heat treated, close-grained cast iron and are precision ground. Unit is 37½ in. high, weighs 600 lb. Taft-Peirce Mfg. Co., Woonsocket, R. I.

PORTABLE ELECTRIC SHEAR. New unishear cuts 14-gage hot rolled steel at 15 to 20 fpm. Blade motion feeds in work so little effort is required by operator in cutting straight lines, curves, angles and notches. Universal motor operates on 115, 220, 230 or 250-volt, d-c or a-c, 60 cycles or less. Minimum radius of left-hand cut, ½-in.; minimum radius of right-hand cut, 1¼ in. Net weight, 9½ lb. Stanley Electric Tools, New Britain, Conn.

DRILLING AND TAPPING UNIT. Standard multiple-spindle drillhead combined with automatic reverse tapping attachment. Unit attaches to any drill press, drills or taps infinite number of patterns. Machine will tap groups of holes on downward stroke, automatically reverses on upward stroke of drill press spindle. Standard models available with 2 to 10 spindles, adjustable from ½-in. minimum centers within 10⅜-in. diameter circle. Capacity, ⅜-in. drills or taps. Thriftmaster Products Corp., Div. of Thomson Industries Inc., Lancaster, Pa.

DOUBLE SPINDLE DISK GRINDER. For high-production grinding of parallel

GASES?



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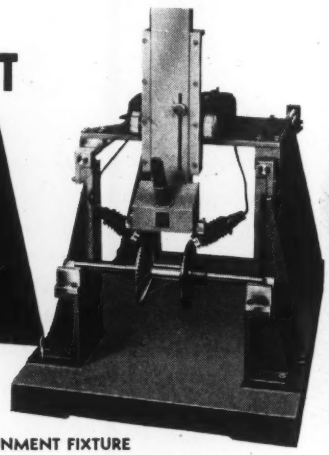

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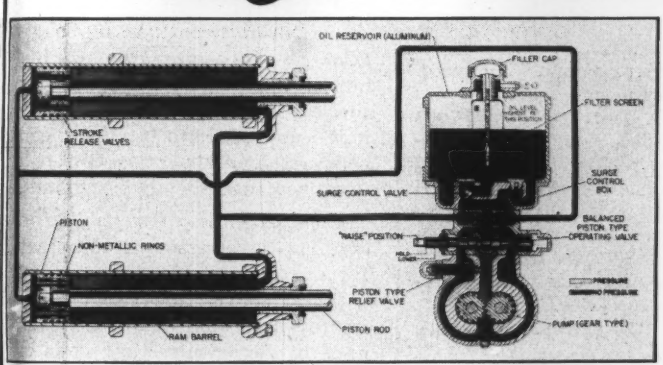

Top Performance Built into Bros Dozers with LPC Hydraulic Units

FOR their *Power-Plus* Bulldozer, Bros engineers wanted speed and power for fast work under heavy loads . . . instant response to controls . . . simple, compact design . . . trouble-free operation. A complete LaPlant-Choate Hydraulic System consisting of jacks and the famous "packaged" hydraulic fluid power unit, was chosen to meet all requirements . . . to make their *good* product still *better.*

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